Economic Impacts of Edwards Aquifer Pumping Restriction Alternatives

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For

Edwards Aquifer Authority Habitat Conservation Plan

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Resource Management. Economic Impact Analysis. Environmental Economics

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EXECUTIVE SUMMARY

This report presents the results of an economic impact analysis for the year 2012 of three Edwards Aquifer withdrawal limit alternatives as part of the development of a Habitat Conservation Plan (HCP) by the Edwards Aquifer Authority (Authority). The Authority must by law implement withdrawal limits on the Edwards Aquifer set at levels below historical use levels to protect the endangered species (Section 3.1.3) that are dependent on the flow of water from Comal and San Marcos Springs. The Authority's enabling legislation (the Act) requires pumping levels to be reduced in two stages, the first to 450k, then to 400k by 2008. The Authority must have a plan in place by 2012 to provide for "the continuing springflow" as required by federal law. In order to evaluate the full economic effects of the pumping limit reductions, this study utilizes an analysis year of 2012. For purposes of the analysis presented here, the annual withdrawal limit HCP alternatives are 400,000 acre-feet per year (a legislative requirement by 2008), for Alternative 1: No Action and Alternative 3: Less Restricted Pumping; 340,000 acre-feet per year for Alternatives 1 and 3 Critical Period reductions; and 175,000 acre-feet per year for Alternative 2: Highly Restricted Pumping. These HCP alternative pumping limitation scenarios were compared to a 2012 water demand of 513,000 acre-feet, a baseline figure predicted by the EDSIMR model. In November 2000 the Authority proposed permits totaling 535,000 acre-feet per year to qualified applications. According to the model's predictions, the baseline demand is approximately 25,000 acre-feet per year lower, at 513,000 acre-feet.

In response to withdrawal limits, water users may buy, sell or lease water rights, implement water conserving management practices or acquire water from other sources to fill the deficit between their demand and their maximum allowable withdrawal. Hence, economic impacts may be quite different for different users. Irrigation users are likely to find it profitable to sell or lease their water rights and change their land uses to less water intensive enterprises such as dryland crops or livestock. Municipal and industrial (M&I) users are more likely to attempt to meet their needs by purchasing water rights, developing alternative sources of supply and implementing water conservation activities such as recycling. All of these economic adjustments will have impacts on the employment of resources, income and welfare of the regional economy.

This study included the following objectives:

1. To estimate the changes in water use and land use by agricultural water users in response to alternative aquifer withdrawal limits;
2. To estimate the employment, labor income and resource income changes within the regions of the HCP Planning Area, and
3. To estimate economic impacts of withdrawal limits for municipal and industrial water users in terms of changes in water supply sources, water prices and the implicit loss of net economic benefits (real income) due to the increased cost of alternative water supply sources to meet demand levels projected by the South Central Texas Regional Water Planning Group (SCTRWPG).

The study area defined for this economic analysis conforms to the HCP Planning Area and includes 17 counties in south-central Texas (see detail map, Figure 3.4-1, Section 3.4.1 of the EIS). These counties were grouped into four regions as follows:

Western Region –Edwards, Kinney, Real and Uvalde
Central Region – Atascosa and Medina
Eastern Region – Bexar, Caldwell, Comal, Guadalupe, Hays, Kendall
Downstream Region – Calhoun, Dewitt, Gonzales, Refugio, Victoria

Economic impact estimates for the entire HCP Planning Area and Regions within the Area are provided in tables and narrative of this report.

Two economic models, EDSIMR and IMPLAN, were used to predict the overall economic impacts of the implementation of each of the HCP pumping limit alternatives, how effects would vary among economic sectors, and the effects of alternative assumptions and scenarios. EDSIMR and IMPLAN were each configured especially for the HCP Planning Area and its regions. EDSIMR is a linear programming model that maximizes the expected net benefits of water use by the municipal, industrial, and agricultural sectors. IMPLAN is a computer algorithm used to devise regional input-output models from local data and the National Input-Out Model, developed and maintained by the U.S. Department of Commerce. A detailed description of EDSIMR is presented in Appendix A-EDSIMR. The IMPLAN model is detailed in Appendix B-IMPLAN.

All of the economic impacts in this analysis relate to either the loss of irrigated acreage and crop production or the need to develop alternative agriculture, municipal, and industrial water supplies to replace Edwards Aquifer supplies which would no longer be available under pumping limitations. These two types of economic impacts are unique and must be estimated independently.

Results of the economic impact analysis using the EDSIMR and IMPLAN models are for the year 2012 and are summarized as follows.

Irrigated Acreage Predictions

Irrigated acreage in 2012 is predicted to be 93,254 acres without pumping limits on the Edwards Aquifer. Feed grains (primarily corn and grain sorghum) and vegetables would be the dominant irrigated crops with 30,415 and 28,092 acres, respectively. Irrigated food grains (mainly wheat and corn for human consumption) production would also be significant with almost 16,000 acres irrigated.

Irrigated crop acreage is predicted to shift to dryland production with implementation of the HCP pumping limits. At an annual limit of 400,000 acre-feet per year, irrigated acreage in the HCP Planning Area would fall to just over 60,000 acres as about 33,000 acres would shift to dryland alternatives.

At an annual aquifer pumping limit of 175,000 acre-feet per year, the predicted shift to dryland alternatives rises to over 72,000 acres and irrigated acreage would be reduced to just over 21,000 acres. Irrigated cotton, oilseeds and other irrigated crops are predicted to virtually disappear from the planning area if this limit were to be imposed. Irrigated food grains and feed grains would fall to only about 10 percent of the acreage predicted with no pumping limits. For cotton, oilseeds and food grains the number of acres predicted to remain in irrigation likely would not be sufficient to sustain a viable agribusiness support industry of input suppliers and first-stage processing.

Western Region: The impacts of pumping limits would vary among the regions of the HCP Planning Area. Modeling results predict that the 400,000 acre-feet per year and 340,000 acre-feet per year annual pumping limits would have minimal impacts on irrigated acreage in the Western Region, where most of the production of irrigated crops is concentrated. However, if a pumping limit of 175,000 acre-feet per year were imposed, irrigated acreage would drop dramatically in the region. Total irrigated acreage is expected to fall from 49,332 acres with no annual pumping limit to 12,109 acres under the 175,000 acre-feet per year limit. Irrigated vegetables would be maintained at about 46 percent of their baseline acreage, while all other irrigated crop acres would fall to 10 percent or less of the acreage predicted under the unlimited pumping scenario.

Central and Eastern Regions: The Central and Eastern Regions are predicted to lose irrigated acreage under both the 400,000 and 340,000 acre-feet per year limits. The results of this analysis suggest that virtually all irrigation water rights in these regions would be transferred to other uses or retired by 2012 under all pumping limit scenarios.

Downstream Region: The Edwards Aquifer pumping limits have no predictable economic impacts on the Downstream Region of the HCP Planning Area within the scope of this economic analysis. The pumping limits would ensure higher springflow levels that would contribute to the flow of water in the rivers fed by the springs. Municipalities, industries and farmers who use river water would have more available supply (see Section 4.3.1 of the EIS). Whether or not they would use this water to an economic benefit would depend upon a myriad of economic variables that are beyond the scope of this project.

Water Use

Water use in the HCP Planning Area would be dramatically different with the imposition of pumping limits. In all but the Downstream Region, water use is predicted to change significantly as the pumping limits of the various alternatives are imposed. Each region would be impacted differently, depending upon geographic location and which economic sector is the major water user in the region.

In the Central and Eastern Regions, irrigation would virtually cease at all pumping limits as Edwards Aquifer water would be transferred to M&I uses. Irrigation water use in the Western Region would remain relatively unaffected at the 400,000 acre-feet per year and 340,000 annual acre-feet per year limits, but would drop sharply under the 175,000 acre-feet limit.

An underlying assumption of the economic analysis was that projected M&I water use in 2012 would be met from either the Edwards Aquifer, new water supplies, or other water management strategies as identified by the SCTRWPG. Hence, reductions in Edwards Aquifer withdrawals would be made up by new water supply options and strategies.

The EDSIMR model selected (from an array of water strategies approved by the SCTRWPG and expected to be implemented by 2012 (Personal comm. F. Arce, San Antonio Water System 2001) those strategies needed for each pumping limit alternative based on an efficiency criterion of meeting the projected demand at the least possible costs. The strategies ultimately implemented by 2012 may differ from those predicted in this analysis. Nevertheless, the predictions provide a guide to selection if cost efficiency is an important criterion.

This analysis predicts that to meet projected 2012 demand in the HCP Planning Area, new supplies of 72,000 acre-feet per year, 117,000 acre-feet per year and 237,000 acre-feet per year will be needed under the 400,000, 340,000 and 175,000 annual acre-feet limits, respectively. The source of these supplies is assumed to be the future options and strategies identified by the SCTRWPG. These strategies have a total supply capacity of 363,672 acre-feet per year that could be developed by 2012.

Regional Economic Impacts Of Reduced Irrigated Crop Production

The predicted reduction in irrigated acreage and water use suggests that farmers likely will adjust by switching land use from irrigated production to dryland alternatives. In the Central and Eastern Regions, some dryland crop production may be the best alternative. In the Western Region, the lack of rainfall limits the dryland crop alternative. The next best possible alternative would likely be livestock production.

As predicted irrigated crop production declines, farmers who might choose to continue farming by shifting resources to dryland farming or livestock would suffer a loss of income since all dryland crop and livestock alternatives are less profitable on a per acre basis. If water rights are sold or leased, the other resources used in production (land, labor, capital and management) would need to find alternative employment or be idled. Hired farm workers would likely be the first and most directly impacted by the cessation of irrigated crop production. Moreover, farm operators who lease land for irrigated crop production would likely be displaced, with limited opportunities for alternative employment of their capital, management and labor.

The leasing or selling of water rights would generate income to land owners, but would not provide the same level of economic support as irrigated farming to the region. These payments would be comparable to transfer payments from other sources, such as Social Security, that may support consumption expenditures in the region, but would not support a productive, basic industry. Moreover, if absentee landowners hold a significant percentage of the water rights, the payments for those rights may exit the area and have no local impact.

Businesses in the area that are dependent upon the irrigated crops sector would suffer a loss in the demand for their goods and services as irrigation water is transferred to alternative uses. Most directly affected would be irrigation equipment suppliers, machinery and equipment dealers, suppliers of seed, fertilizer and chemicals, banks and financial institutions, as well as cotton ginners, grain elevators and other first-stage processing businesses. Such economic impacts are sometimes referred to as "third-party" impacts since these businesses are not parties to the water rights exchange, but would be affected by it.

The EDSIMR and IMPLAN models were used conjointly in the economic impact analysis to estimate the regional secondary or third party impacts that would likely follow the reduction in irrigation water use and acreage as a result of the implementation of the proposed pumping limits under the EAA-HCP. These impacts are expressed in terms of labor employment, labor income and gross regional product. All three indicators of economic impact are predicted to follow closely similar trends under alternative pumping limits. Only employment impacts are discussed in this Executive Summary.

The 400,000 and 340,000 annual acre-feet pumping limits would have relatively minor impacts on irrigation crop related labor employment. Model results predict that under these alternatives job losses would be limited to the Central and Eastern Regions. Labor employment is predicted to fall by 656 jobs, or about 11 percent of the predicted irrigation related employment, without pumping limits. Employment in the Western Region would be relatively unaffected at these two pumping limits.

The 175,000 acre-feet per year pumping limit is predicted to have a significant employment impact on the irrigated crop and related agribusiness industry within the HCP Planning Area. Total irrigation related jobs are predicted to fall to 2,962, or less than one-half the predicted level of 6,156 jobs, without pumping limits (Table 4-12).

In the Western Region, this impact would be even more significant as the number of jobs is predicted to fall by 2,608 to 1,990, or 43 percent of the predicted employment, without pumping limits. The predicted loss of jobs in the Western Region under the 175,000 acre-feet per year pumping limit is about 25 percent of the 10,433 total jobs reported for the region in 1997 by the Texas Workforce Commission (TWC). However, this comparison may be misleading since many of the on-farm jobs would not be included in the TWC employment statistics.

The job loss prediction also includes permanent, full time employees of farms, irrigation equipment suppliers, commodity processors and other businesses closely related to irrigated crops as well as "main street" enterprises including consumer goods and services establishments. This magnitude of change would affect not only agribusinesses closely related to irrigated crops but also the "main street" businesses such as retail establishments, banks and financial institutions and other businesses that provide personal and business services to the general population of the region.

A compounding factor to this predicted employment impact is that many of the lost jobs would likely be relatively low paying and occupied by persons with limited skills and alternative employment opportunities. In the short run, the increase in unemployment could strain the public welfare facilities and services in the Western Region. Without a substitute industry for irrigated crops to support the economic base of the region, an out-migration of laborers and their families may occur.

Economic Impacts On Municipal And Industrial (M&I) Users

The primary indicators of economic impacts on municipal and industrial (M&I) users predicted in this analysis were the higher prices that would be necessary to pay for the costs of alternative water supply management strategies and the loss of net economic benefits or real income to M&I consumers who would be forced to pay higher prices. It is assumed in the analysis that, even facing higher water prices, M&I consumers would continue to use water at the per capita rate projected by the Texas Water Development

Board (TWDB). It is further assumed that the M&I water demands projected by the SCTRWPG would be met by developing alternative supplies. Hence, there were no predicted losses in jobs and income in the non-agricultural economy.

Impact On M&I Water Prices

Water prices to M&I users are predicted to rise only modestly under the 400,000 and 340,000 annual acre-feet pumping limits in all regions of the HCP Planning Area. For example, under the 340,000 annual acre-feet pumping limit, predicted 2012 prices rise by about 37 percent in the Eastern Region above prices predicted without a pumping limit on the Edwards Aquifer (Table 4-15). This translates to an increase in water rates of about $0.80, from $2.15 to $2.95 per 1,000 gallons in the 400,000 and 340,000 alternatives. This is a relatively modest increase that likely could be absorbed into the large Eastern Region water market with little difficulty. Increases in prices in the Western and Central Regions are predicted to be similar but slightly higher.

At an annual pumping limit of 175,000 acre-feet per year, M&I prices are predicted to rise more significantly. In the Eastern Region, where most of the municipal and industrial consumption occurs, predicted prices would nearly double from $701 per acre-foot with no Edwards Aquifer pumping limit to $1,389 per acre-foot. M&I prices would more than double in the Western and Central Regions at this pumping limit.

These predicted water prices were derived from the assumption that the HCP Planning Area water demands in 2012, as projected by the SCTRWPG, would be met with new water supplies and management strategies without regard to the price of the water to M&I consumers. This assumption seems plausible under the 400,000 and 340,000 annual acre-feet limits where the predicted increases in water prices are relatively modest and would not likely trigger a significant reduction in water demand. However, if the price of water must double to pay for new supply developments to meet the 175,000 acre-feet per year annual limit, M&I consumers are likely to reduce their demand for water. Results of previous research suggest that with a doubling of water price, total water demand may be reduced by as much as 30-35 percent (Griffin & Chang, 1991). This reaction on the part of M&I water consumers could reduce the need for some of the more expensive supply management strategies suggested by the SCTRWPG. It would also reduce the economic impacts predicted in this economic impact study.

Impact On Annual Net Economic Benefits To M&I Users

The use of water in industrial plants, commercial businesses, energy generation, households and other M&I uses generates income and net benefits above the cost. This is a common economic indicator of economic welfare, which may be expressed as annual water use net benefits to M&I users. Similar benefits exist for irrigation users and can be expressed as net farm income. However, farm income is a part of the economic impacts reported earlier under **Regional Economic Impacts of Reduced Irrigated Crop Production** and are not repeated here.

If the cost of water increases because of higher prices for the same end uses, benefits derived from using water decline. The change in benefits is a loss to water consumers, which may alternatively be thought of as a reduction in water consumers' real income.

With no limit on Edwards Aquifer pumping, the predicted net economic benefits to M&I users would be $970 million in 2012 (in year 2000 dollars). Most of these benefits are in the municipal sector, including residential and commercial users. Net benefits are predicted to fall under each of the proposed pumping limits as more expensive water management strategies are developed to replace Edwards Aquifer water and the cost of meeting M&I demand rises. These changes would be relatively minor for the 400,000 and 340,000 acre-feet per year limits as annual net benefits would be reduced by less than one percent.

Under an annual pumping limit of 175,000 annual acre-feet, 2012 predicted net benefits to M&I water users would fall to $877 million, a drop of 10 percent from the level with no pumping limit. This would amount to a loss in real income of $93 million per year for M&I users in the HCP Planning Area.

1.0 INTRODUCTION

This report presents the results of an economic impact analysis conducted to predict the economic impacts of three Edwards Aquifer withdrawal limit alternatives formulated as a part of the development of a Habitat Conservation Plan (HCP) for the Edwards Aquifer Authority (Authority). The HCP is designed to protect the endangered species that are dependent on the flow of water from Comal and San Marcos Springs. Historically, the Edwards Aquifer has served as the major source of water supply in the south-central region of Texas, ranging roughly from Uvalde in the west to the San Antonio, New Braunfels and San Marcos areas in the east. The aquifer supports a wide variety of economic enterprises including irrigated crops, industry, mining, utilities, recreation and municipal uses. As economic and population growth continue in the region, demands on the aquifer are projected to exceed recharge in some years so that all historical uses cannot be maintained at all times at the same levels solely from the aquifer.

The Authority, as mandated by the Edwards Aquifer Authority Act, will establish withdrawal limits on the aquifer at levels below historical use. This means that all of the historical economic activities that have been dependent on water from the aquifer can no longer be supported at previous levels and economic adjustments will be made. The proposed withdrawal limits are likely to be in terms of some total or proportional allocation on all water users. However, since water marketing exists among users in the HCP Planning Area, and since water may be acquired from outside the region, the economic impacts of adjusting to the proposed HCP pumping limits may not be proportional among users. In response to imposed limits, water users may buy, sell or lease water rights, implement water conserving management practices, or acquire water from other sources to fill the deficit between their demand and their maximum withdrawal limit. Hence, economic impacts may be quite different for different users.

Irrigation users are likely to respond to pumping limits and higher water prices by evaluating the financial returns from continuing irrigated farming versus selling or leasing their water rights and changing land use to less water intensive enterprises such as dryland farming or livestock production. Municipal and industrial (M&I) users are more likely to meet their needs by purchasing water rights, developing alternative sources of supply, and implementing water conservation activities such as recycling.

1.1 Economic Impact Analysis Objectives

The analysis presented herein uses economic models that take into account alternative water management strategies that are likely to be adopted by current and future water users in response to proposed HCP pumping limits, and predicting the subsequent economic impacts on major water using sectors within the regions of the HCP Planning Area.

This economic impact analysis includes the following objectives:

- To estimate the changes in water use and land use by agricultural water users in response to alternative aquifer withdrawal limits;
- To estimate the employment, labor income and resource income changes within regions of the HCP Planning Area where the shift from irrigated agriculture to alternative land uses is significant; and
- To estimate the economic impacts of withdrawal limits on municipal and industrial water users in terms of changes in water supplies, water prices and the implicit loss of net economic benefits (real income) due to the increased cost of alternative water supply sources to meet projected water demand.

2.0 STUDY AREA

The area defined for this economic analysis conforms to the HCP Planning Area and includes 17 counties in south-central Texas. These counties are grouped into four regions:

Western Region – Edwards, Kinney, Real, and Uvalde

Central Region – Atascosa and Medina

Eastern Region – Bexar, Caldwell, Comal, Guadalupe, Hays, Kendall

Downstream Region – Calhoun, Dewitt, Gonzales, Refugio, Victoria

A detailed map of the HCP Planning Area and the four regions is shown in Figure 3.4-1 of the EIS to which this economic analysis is appended. Section 3 of the EIS provides a detailed discussion of the historical and current economy, demographics, agriculture sector, land use and other characteristics of the planning area. Economic predictions in this analysis relate directly to the planning area that is described in the EIS. Results in the following sections of this economic analysis are presented for each region and for the overall HCP Planning Area.

3.0 METHODS

3.1 Assumptions

In this economic impact analysis, assumptions were required concerning the alternative Edwards Aquifer water withdrawal limits to be imposed, water demand levels, permit holder's economic goals and flexibilities, characteristics of the Edwards Aquifer and other issues. Major assumptions underlying this economic impact analysis are discussed below.

3.1.1 Edwards Aquifer Withdrawal Limits

For this study, several alternative withdrawal limits were evaluated, including 400,000; 340,000; and 175,000 acre-feet per year by the year 2012. These limits were compared to a baseline 2012 water demand from the Edwards Aquifer of 513,000 acre-feet per year without the imposition of limits, as predicted by the EDSIMR model. The Aquifer Authority already proposed restricting permits to 535,000 acre-feet per year. The three pumping limit scenarios mentioned above were evaluated with respect to their impacts on the HCP Planning Area's economic sectors. Economic impacts were estimated as the difference between the predicted values of economic variables under the no limit scenario (baseline) and predicted values under each of the scenarios that limit withdrawals. All predicted impacts were for the year 2012.

3.1.2 Water Demand

For municipal, industrial, mining, and utility demand (M&I), the official water demand projections made by the TWDB for Region L and adopted by the SCTRWPG are used in the models. For each pumping limit scenario, it was assumed that the projected M&I demand levels for each region and the overall HCP Planning Area would be met from either (1) the proposed Edwards Aquifer pumping limit supply; (2) existing surface water supplies; or (3) existing and future water management strategies (see Table 3-1). These projections assume that M&I water users will consume water at about the same per capita rate as at present. Water demand for the year 2012 was estimated by interpolation of the SCTRWPG projections for the years 2010 and 2020.

Table 3-1. Summary of Existing and Future Water Management Strategies included in EDSIMR for the HCP Planning Area, 2012.

Existing Water Management Strategies		
1.	SSWSP	Schertz-Seguin water supply project
2.	WCRWSP	Western Canyon Regional water supply project
3.	DUNLAP	Lake Dunlap water treatment plant
4.	BMWDczo	Carrizo Aquifer
5.	BMWDtri	Trinity Aquifer
6.	GBRA	GBRA Canyon Reservoir
7.	HayI35	Hays/IH35 water supply project
Future Water Management Strategies (included in EDSIMR)		
8.	L-10 Municipal	Municipal demand conservation
9.	L-10 Irrigation	Irrigation water conservation
10.	L-15	Transfer Edwards Aquifer irrigation rights to municipal use
11.	L-18a	Edwards Aquifer recharge from natural drainage
12	G-15C	Canyon Reservoir river diversions
13.	SCTN-16	Lower Guadalupe River diversions
14.	CZ-10C	Carrizo Aquifer - Wilson and Gonzales Counties
15.	CZ-10D	Carrizo Aquifer - Gonzales and Bastrop Counties

Table 3-1. Summary of Existing and Future Water Management Strategies included in EDSIMR for the HCP Planning Area, 2012 (continued)

16.	SCTN-3C	Simsboro Aquifer
17.	SAWS	Recycled water program
18.	SCTN-6A	Recirculation*
Future Water Management Strategies (not included in EDSIMR)		
19. LCRA Lower Colorado river diversion		
20. Purchase water from a major provider		
21. SCTN-17 Seawater desalination		

Source: HDR 2000 as modified by Appendix A.

*Not in current SCTRWPG Water Plan, but was originally recommended by EAA.

For irrigation water demand, the assumptions and methods in this economic analysis produce a different outcome from that of the projected demand adopted by the SCTRWPG and TWDB. The demand projections from the SCTRWPG were made for irrigated agriculture independent of the demands of other economic sectors, the rising price of water in the area, and without considering the potential demand reducing effects of limitations on withdrawals from the Edwards Aquifer. Hence, the SCTRWPG projections reflect a physical water demand potential that could be used for irrigation on the available land area. About 300,000 acre-feet of potential irrigation water use is projected for 2012 (Interpolated from Appendix A). However, for the economic impact analysis presented here, models considered the interaction of market forces, and the cost of existing water and alternative water supplies in order to predict irrigation demand (Tables 4-7 through 4-10).

This economic impact analysis, therefore, treats irrigation demand for water as a *derived demand* that is sensitive to several economic factors, including: (1) the cost of pumping; (2) increased yields achieved from applying irrigation water; (3) the value (price) of commodities produced; and (4) the value of alternative uses of irrigation water, including the sale or lease to non-irrigation water users. Irrigation permit holders are assumed to be rational economic decision-makers who will act in their own interests and allocate the water they own among all available uses to gain the highest possible financial gain. Irrigation demand is interdependent with the demands and actions of other, non-irrigation water users that may provide alternative opportunities for the water. Hence, for each withdrawal limit, the quantity of water demanded for irrigation depends upon the relative profitability of growing irrigated crops versus the monetary returns that can be gained by leasing or selling water rights. It is assumed that the value of water in the planning area will rise faster than the profitability of irrigated crops. Hence, as pumping limits become more stringent, irrigation water rights will likely be leased or sold to M&I users.

An important assumption in the economic analysis relates directly to the transfer of irrigation water rights. The Edwards Aquifer Authority Act (the Act) created by House Bill 1477 (74th Texas Legislature) contains a restriction on the sale or lease of irrigation rights such that at least one acre-foot of water right must remain with each acre of irrigation land permitted. Hence, if a farmer receives a permit for two acre-feet of water per acre on his farm, only one acre-foot may be sold or leased. However, the law is not specific about whether or not the Authority may retire the remaining acre-foot per acre if it chooses to do so in order to maintain aquifer levels and satisfy springflow requirements under the law. For purposes of this analysis, it was assumed that, by 2012, the Authority would purchase and retire the rights to the one acre-foot that is attached to irrigated land within the planning area, thereby reducing this component of overall regional demand.

3.1.3 Water Supply

Water supply in the HCP Planning Area is primarily from the Edwards Aquifer with lesser amounts from various sources of surface water. As restrictions are imposed on withdrawals from the Edwards, alternative sources of supply will need to be developed to meet projected demand. The planning process to meet projected supply shortages has been underway since the mid-1980s. Major water suppliers and users in the region have worked together to identify water supply management strategies for meeting current and future needs. The most recent effort, under the auspices of Senate Bill 1 (75th Texas Legislature), produced a regional water supply plan for the SCTRWPG area (HDR 2000) which fully encompasses the HCP Planning Area.

This economic analysis assumed that all of the water management strategies recommended by the SCTRWPG and that could be made available by 2012 would be implemented if necessary to meet projected demand. The EDSIMR model selected among the identified strategies based on the amount and location of demand and the relative cost (in year 2000 dollars) of water from each strategy. Hence, it was assumed that the development of alternative strategies would be staged such that strategies offering the highest ratio of benefits to costs to water consumers would be selected first. More expensive projects would be added to the supply as required to meet demand growth. Water management strategies included as viable alternative water sources in the economic analysis are listed in Table 3-1. Seven existing water management strategies (#1-7) which are already underway are assumed to be a part of the existing water supply in the HCP Planning Area by 2012.

Three future water management strategies recommended by the SCTRWPG were not included in the present analysis because it was believed that they would not be implemented by 2012 (19 & 21) or because they are still under development and complete information is not available (20) (Table 3-1).[1]

3.2 Economic Analysis Models

Two economic models, EDSIMR and IMPLAN, were used to predict the overall economic impacts of each of the HCP pumping limit alternatives, how effects vary among sectors, and the effects of alternative assumptions and scenarios. EDSIMR and IMPLAN were each configured especially for the four regions within the HCP Planning Area.

[1] Recent negotiations between the LCRA and the San Antonio Water System suggest that some version of Strategy 19, LCRA Lower Colorado River Diversion might be implemented by 2012, but as an agreed upon development schedule has not been confirmed, the option was not included in this analysis.

3.2.1 EDSIMR

The original EDSIM model (for Edwards Simulation) was developed in the early 1990s by researchers at Texas A&M University as a tool to assess the economic implications of Edwards Aquifer management. It has been applied numerous times to assist with water management problems in the Edwards Aquifer area. EDSIMR is a demand driven, optimization model built to simulate the activities and responses of agricultural producers to changes in water management strategies for the Edwards Aquifer. A complete description of the EDSIMR model used in this economic analysis is presented in **Appendix A** of this report.

For this economic analysis, the model was modified to simulate (1) the direct regional economic effects of the alternative withdrawal limits; (2) an associated creation of a marketplace allowing trading of withdrawal rights (e.g., agriculture to municipal); and (3) the development of alternative water supplies as proposed by the SCTRWPG. The model was also extended to include the Downstream Region and other counties as defined for the HCP Planning Area.

The EDSIMR model results should not be taken as quantitatively precise estimates of economic responses of any specific farm or business to aquifer management strategies. For example, EDSIMR predictions of actions and responses of crop irrigators in a particular county and aquifer setting are based on their aggregate average history of cropping patterns and water use. Individual practices may not conform to these averages. The model is sensitive to important input assumptions, such as the price at which Edwards Aquifer water rights would trade. Since water markets in the area are new, current price information is limited and values for these inputs can only be approximated. As the market for water rights matures, the precision of input values and resulting model predictions will also improve.

3.2.2 IMPLAN

IMPLAN is a generalized regional input-output model that can be used to calculate how an initial change in one economic sector (such as agriculture) can ripple through the economy causing changes in sales, income and employment of resources such as labor, capital and management. Like EDSIM, IMPLAN has been used to estimate economic impacts of various policies affecting the Edwards Aquifer in the past. A complete description of the IMPLAN model used in this economic analysis, with references to previous applications, is presented in **Appendix B** of this report.

For this economic analysis, an IMPLAN input-output model was built for the HCP Planning Area. The model was used to predict how restrictions on Edwards Aquifer pumping would impact future irrigated acreage and production in the agricultural sector, with consequent impacts on businesses that supply inputs and services to irrigation farmers or provide the initial processing of irrigated agricultural crops. All such interrelated businesses will experience reductions in their volume of business if irrigated acreage is reduced.

The input-output analysis of the HCP Planning Area IMPLAN model is a logical extension of the estimated agricultural production impacts provided by EDSIMR. For purposes of the present analysis, EDSIMR and IMPLAN were conjoined to estimate impacts on the agricultural sector as well as impacts on regional employment, income and gross regional product.

4.0 ANALYSIS OF ECONOMIC IMPACTS

Regional economic impacts on irrigated agriculture and related agribusiness sectors arising from alternative restrictions on Edwards Aquifer water withdrawals were estimated in terms of local losses of agricultural value of production, irrigated crop acreage and related impacts on employment and income. Predicted impacts are presented for both the HCP Planning Area and for each of the regions where appropriate.

4.1 Impacts on Irrigated Crop Acreage for the HCP Planning Area

Acreage in the HCP Planning Area devoted to irrigated crop production is predicted to change significantly under the three pumping limit alternatives analyzed in this study. Predicted 2012 irrigated acreage under each pumping limit alternative for the HCP Planning Area is presented in Table 4-1.

Table 4-1 Irrigated crop acreage and acreage shifted to dryland production under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1&3)	340 (Critical Period Base ** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	28,092	24,820	24,666	12,901
Cotton	6,981	4,053	3,871	908
Feed Grains	30,415	13,600	12,651	3,905
Food Grains	15,697	11,448	11,195	1,915
Oil Seeds	4,307	2,829	2,781	434
Others	7,762	3,478	3,222	1,108
All Irrigated Crops	93,254	60,228	58,386	21,171
Acres Shifted to Dryland Production	0	33,026	34,868	72,083
All Crops	93,254	93,254	93,254	93,254

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Results from four pumping scenarios are shown. Without a pumping limit, total predicted irrigated acreage using water from the Edwards Aquifer in 2012 is predicted to be 93,254 acres. Feed grains and vegetables would be the dominant irrigated crops with 30,415 and 28,092 acres, respectively. Irrigated food grain production would be significant also with almost 16,000 acres. Cotton is predicted to be a distant fourth with almost 7,000 irrigated acres in 2012 (Table 4-1).

Irrigated crop acreage is predicted to shift to dryland production from the very beginning of the implementation of alternative pumping limits. At a limit of 400,000 acre-feet per year, irrigated acreage in the HCP Planning Area would fall to just over 60,000 acres as about 33,000 irrigated acres would shift to dryland production. Acreage in all irrigated crops would decline under the 400,000 acre-feet per year pumping limit. Most of the shift would come from irrigated feed grains, with significant amounts of vegetables, cotton and food grains acreages also changing to a dryland alternative (Table 4-1).

Very little change in irrigated acreage is predicted if the pumping limit is reduced from 400,000 acre-feet per year to 340,000 acre-feet per year. However, with a limit of 175,000 acre-feet per year, the number of acres predicted to shift to dryland alternatives rises to over 72,000. Irrigated acreage would drop to just over 21,000 acres, about 23 percent of the predicted acreage with unlimited pumping from the Edwards Aquifer. Irrigated cotton, oilseeds and other irrigated crops would virtually disappear from the planning area, with irrigated food grains and feed grains predicted to fall to only about 13 percent of the 46,112 acres predicted with no pumping limits.

In the case of cotton, it is predicted that irrigated acreage would fall to less than 1,000 acres in the HCP Planning Area under the 175,000 annual acre-feet pumping limit. Production from this relatively small amount of acreage likely would not be sufficient to support the area's first stage processing business – cotton ginning. Since the bulkiness of raw cotton limits the distance it can be feasibly hauled, cotton production could leave the area completely. Acreage of other irrigated crops, such as food grains and oilseeds are also predicted to be near or below the threshold acreage required to support related infrastructure. The loss of handling and processing infrastructure could mean that these crops could no longer be produced in the area, even though they would be profitable farming enterprises on a limited number of acres.

4.2 Impacts on Irrigated Crop Acreage – Regions of the HCP Planning Area

Tables 4-2 through 4-5 present the 2012 predicted impacts of proposed aquifer pumping limit alternatives on irrigated crop acreages in the regions of HCP Planning Area. Table 4-2 presents predictions for the Western Region including Uvalde, Edwards, Kinney and Real Counties. Vegetables are the predominant irrigated crops in this region, but food grains are also important.

Table 4-2 Irrigated crop acres and acreage shifted to dryland production in the EAA Western Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1, 000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	20,682	20,681	20,678	8,913
Cotton	3,336	3,336	3,335	372
Feed Grains	9,844	9,844	9,844	1,099
Food Grains	10,446	10,446	10,446	1,165
Oil Seeds	2,643	2,643	2,643	295
Others	2,381	2,381	2,380	265
All Irrigated Crops	49,332	49,331	49,326	12,109
Acres Shifted to Dryland Production	0	0	0	37,223
All Crops	49,332	49,331	49,326	49,332

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Predicted irrigated acreage in the Western Region is affected very little by the 400,000 acre-feet per year and 340,000 acre-feet per year aquifer pumping limits. Predicted acreages of all irrigated crops for these alternatives do not change from the prediction of 49,332 acres with no pumping limit. However, if a limit of 175,000 acre-feet per year were imposed, irrigated acreage would drop dramatically in the region. Total irrigated acreage would drop from 49,332 acres with no limit to 12,109 acres under the 175,000 acre-feet per year limit. Irrigated vegetables would be maintained at about 40 percent of their original acreage, while all other irrigated crop acres would fall to 10 percent of the acreage predicted with no limit on pumping (Table 4-2).

Irrigated acreage in the Central and Eastern Regions is predicted to drop significantly with the imposition of the 400,000 acre-feet per year limit (Tables 4-3 and 4-4). In the Eastern Region all irrigated crops, except vegetables and feed grains, are predicted to fall to less than 1,000 acres.

Table 4-3 Irrigated crop acres and acreage shifted to dryland production in the EAA Central Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1, 000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	2,895	2,267	2,267	2,267
Cotton	3,643	716	534	534
Feed Grains	15,730	3,089	2,306	2,306
Food Grains	5,039	999	746	746
Oil Seeds	1,366	185	139	139
Others	4,655	924	690	690
All Irrigated Crops	33,328	8,180	6,682	6,682
Acres Shifted to Dryland Production	-	25,148	26,646	26,646
All Crops	33,328	33,328	33,328	33,328

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-4 Irrigated crop acreage and acreage shifted to dryland production in the EAA Eastern region under Edwards Aquifer pumping limits, 2012 projected.

Irrigated Crop Acreage	Annual Pumping Limit (1, 000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1&3)	340 (Critical Period Base ** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	4,516	1,872	1,721	1,721
Cotton	-	-	-	-
Feed Grains	4,774	600	433	433
Food Grains	209	-	-	-
Oil Seeds	298	-	-	-
Others	621	68	47	47
All Irrigated Crops	10,418	2,540	2,201	2,201
Acres Shifted to Dryland Production	-	7,878	8,217	8,217
All Crops	10,418	10,418	10,418	10,418

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Irrigated vegetable acreage would remain relatively stable in the Central Region with a predicted drop of about 20 percent from the baseline acreage of 2,895 acres. Predicted irrigated feed grain acreage would fall from almost 16,000 acres with no limit to about 3,000 acres under the 400,000 acre-feet per year pumping limit, and to 2,306 acres under the 340,000 acre-feet per year and 175,000 acre-feet per year limits (Table 4-3). Irrigated cotton, food grains, oilseeds and other crops acreage in the Central Region are predicted to fall to levels so low under the 175,000 acre-feet per year pumping limit that it may not be possible to maintain a viable agribusiness industry including processing, marketing and input supply.

In the Eastern Region, irrigated crop acreage is predicted to fall sharply with the implementation of the 400,000 acre-feet per year pumping limit from the predicted acreage with no limit on pumping from the Edwards Aquifer. Irrigated production is predicted to all but cease for all crops except vegetables, which would be maintained at less than one-half the acreage of 4,516 acres predicted with no limit on aquifer withdrawals (Table 4-4).

Table 4-5 presents the predicted impacts for the Downstream Region of the HCP Planning Area. However, this region is predicted to have very few irrigated acres in 2012 and none that are irrigated from the Edwards Aquifer. Hence, it is predicted to be unaffected by the pumping limits analyzed in this study.

Table 4-5 Irrigated crop acres and acreage shifting to dryland production in the EAA Downstream Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1, 000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	0	0	0	0
Cotton	0	1	1	1
Feed Grains	67	67	67	67
Food Grains	0	3	3	3
Oil Seeds	0	0	0	0
Others	104	104	104	104
All Irrigated Crops	171	175	175	175
Acres Shifted to Dryland Production	0	0	0	0
All Crops	171	175	175	175

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

The predicted acreage shifts away from irrigated crops and to dryland crops or livestock enterprises can be expected to have a major negative impact on the agricultural sector and on businesses that depend on irrigated agriculture in the HCP Planning Area. This impact is most significant in the Central and Eastern Regions for the annual pumping limits of 400,000 acre-feet per year and 340,000 acre-feet per year, as irrigated agricultural production is predicted to fall to only a fraction of the level predicted for 2012 without annual pumping limits. The Western Region of the planning area is less affected at these withdrawal limits, but would be significantly impacted by an annual limit of 175,000 acre-feet.

4.3 Impacts on Water Use – HCP Planning Area

The first column of Table 4-6 indicates the 2012 predicted water demand from various sources without limits on pumping from the Edwards Aquifer. The Edwards Aquifer is predicted to supply 513,000 acre-feet per year of the total projected demand of 649,000 acre-feet per year in 2012. The remaining demand for 2012 is predicted to be met by 98,000 acre-feet per year of water from existing surface sources (assumes implementation of Region L Water Plan Strategy G-15C and TNRCC approval of GBRA's application to amend Certificate of Adjudication No. 18-2074 to increase the authorized water supply yield of Canyon Reservoir (EIS Appendix B), and 38,000 acre-feet from current supply strategy developments (as shown in Table 3-1) that are projected to be complete by 2012.

Table 4-6 HCP Planning Area water use under alternative Edwards Aquifer pumping limits, 2012 predicted.

Water Source : (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Edwards Aquifer	513	400	340	175
Current Development	38	38	38	38
Future Development	0	72	117	237
Existing Surface	98	98	98	98
Region Wide Total	649	608	593	548

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Total region wide water use is predicted to decline under each of the proposed alternative pumping limits. This reduction would stem entirely from the shift of irrigated acreage to dryland alternatives since the projected M&I demand is assumed to be fully met for each alternative pumping limit. Total use in 2012 is predicted to decline 16 percent from 649,000 acre-feet with no limits on Edwards Aquifer pumping to 548,000 acre-feet under the 175,000 acre-feet per year pumping limit.

Under the increasingly restrictive pumping limits, less Edwards Aquifer water would be available and future development of alternative supplies must be brought on line to meet demand. This analysis predicts that to meet projected demand in the HCP Planning Area, new annual supplies of 72,000 acre-feet, 117,000 acre-feet and 237,000 acre-feet would be needed under the 400,000, 340,000 and 175,000 acre-feet per year pumping limit alternatives, respectively (Table 4-6).

4.4 Water Use by Region, Economic Sector and Source of Supply

Predicted water use in each HCP Planning Area Region by major economic sector and source of supply is shown in Tables 4-7 through 4-10. In all but the Downstream Region, water use is predicted to change significantly as the alternative pumping limits are imposed. Each Region would be impacted differently, depending upon its location and which economic sector is the major Edwards Aquifer water user.

Table 4-7 Annual water use by sector and source in the Western Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Water Source: (1,000 acre-feet)				
Agriculture:				
Edwards Aquifer	42	34	29	2
Current Development	0	0	0	0
Future Development	0	6	6	6
Existing Surface	1	1	1	1
Agriculture Total	43	41	36	8
Municipal:				
Edwards Aquifer	7	5	3	3
Current Development	0	0	0	0
Future Development	0	2	4	4
Existing Surface	0	0	0	0
Municipal Total	7	7	7	7
Industrial:				
Edwards Aquifer	1	1	1	0
Current Development	0	0	0	0
Future Development	0	0	0	0
Existing Surface	0	0	0	0
Industrial Total	1	1	1	0

Table 4-7 Annual water use by sector and source in the Western Region under alternative Edwards Aquifer pumping limits, 2012 predicted (continued).

Total of All Sectors:				
Edwards Aquifer	50	40	33	5
Current Development	0	0	0	0
Future Development	0	8	10	10
Existing Surface	1	1	1	1
Western Region Total	51	48	43	16

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-8 Annual water use by economic sector and source in the Central region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source: (1,000 acre-feet)				
Agriculture:				
Edwards Aquifer	31.4	0.6	0.0	0.0
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	4.7	4.2	4.2
Existing Surface	11.2	11.2	11.3	11.3
Agriculture Total	42.5	16.5	15.5	15.5
Municipal:				
Edwards Aquifer	7.8	6.2	4.3	4.1
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	1.6	3.5	3.7
Existing Surface	0.0	0.0	0.0	0.0
Municipal Total	7.8	7.8	7.8	7.8
Industrial:				
Edwards Aquifer	0.3	0.2	0.2	0.1
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	0.1	0.1	0.1
Existing Surface	0.0	0.0	0.0	0.0
Industrial Total	0.3	0.3	0.3	0.2

Table 4-8 Annual water use by economic sector and source in the Central region under alternative Edwards Aquifer pumping limits, 2012 predicted (continued).

Total of All Sectors:				
Edwards Aquifer	39.5	7.0	4.4	4.2
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	17.5	7.8	7.9
Existing Surface	11.2	11.2	11.3	11.3
Central Region Total	50.6	35.7	23.5	23.4

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-9 Annual water use by economic sector and source in the Eastern Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source: (1,000 acre-feet)				
Agriculture:				
Edwards Aquifer	11	0	0	0
Current Development	0	0	0	0
Future Development	0	2	2	2
Existing Surface	15	15	15	15
Agriculture Total	27	17	17	17
Municipal:				
Edwards Aquifer	336	282	241	123
Current Development	37	37	37	37
Future Development	0	65	97	216
Existing Surface	0	0	0	0
Municipal Total	374	384	376	376
Industrial:				
Edwards Aquifer	76	71	62	43
Current Development	1	1	1	1
Future Development	0	0	0	2
Existing Surface	0	0	0	0
Industrial Total	78	72	63	47

Table 4-9 Annual water use by economic sector and source in the Eastern Region under alternative Edwards Aquifer pumping limits, 2012 predicted (continued).

Total of All Sectors:				
Edwards Aquifer	424	353	303	166
Current Development	38	38	38	38
Future Development	0	67	99	219
Existing Surface	16	16	16	16
Eastern Region Total	478	474	456	439

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-10 Water use by sector and source in the Downstream Region under alternative Edwards Aquifer Pumping Limits, 2012 projected.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Water Source (1,000 acre-feet):				
Agriculture:				
Edwards Aquifer	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0
Existing Surface	0.2	0.2	0.2	0.2
Agriculture Total	0.2	0.2	0.2	0.2
Municipal:				
Edwards Aquifer	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0
Existing Surface	17.5	17.5	17.5	17.5
Municipal Total	17.5	17.5	17.5	17.5
Industrial:				
Edwards Aquifer	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0
Existing Surface	52.3	52.3	52.3	52.3
Industrial Total	52.3	52.3	52.3	52.3

Table 4-10 Water use by sector and source in the Downstream Region under alternative Edwards Aquifer Pumping Limits, 2012 projected (continued).

Total of All Sectors:				
Edwards Aquifer	0	0	0	0
Current Development	0	0	0	0
Future Development	0	0	0	0
Existing Surface	70	70	70	70
Downstream Region Total	70	70	70	70

Source: EDSIMR predictions

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Irrigation is the dominant water use in the Western Region and virtually all of the supply for this purpose is pumped from the Edwards Aquifer (Table 4-7). Predicted 2012 water use from the aquifer is over 42,000 acre-feet. This use would decline under each of the more restrictive annual pumping limits, but would remain at almost 30,000 acre-feet under the 340,000 acre-feet per year limit. This is primarily due to the region's remoteness from San Antonio, the major M&I demand center, and to the irrigated crop pattern consisting primarily of high value vegetables.

Irrigation water use in the Western Region is predicted to drop to less than 2,000 acre-feet in 2012 if the 175,000 acre-feet per year limit is imposed (Table 4-7). As indicated earlier, under this limit most irrigated cropland would likely be shifted to a dryland alternative, such as livestock production. At this low level of water use and acreage in irrigation, it is doubtful that irrigated production could continue in the Region because the low volume of output likely would not sustain a viable support industry of agribusiness suppliers and processors.

Water used for irrigation in the Eastern and Central Regions would be the first significant reduction of Edwards Aquifer water use reduction under the proposed limits. Irrigated agriculture is the major water use in the Central Region. Predicted irrigation demand under no pumping limits for 2012 is 42,500 acre-feet out of a total regional demand of 50,600 acre-feet (Table 4-8). About three-fourths of the 2012 predicted irrigation water use in the Region would be supplied from the Edwards Aquifer under the baseline scenario of no pumping limits.

However, for a limit of 400,000 acre-feet per year and below, pumping from the aquifer for irrigation purposes in the Central Region is predicted to cease. Similarly in the Eastern Region irrigation is predicted to become insignificant or cease under all proposed Edwards Aquifer pumping limits (Table 4-9).

Table 4-10 presents predicted water use in the Downstream Region. However, this region is predicted to remain unaffected by the proposed Edwards Aquifer limit alternatives analyzed in this study. It is recognized in the EIS (Section 4.3.1) that the implementation of the proposed pumping limits could increase the quantity of surface water available in this Region. Given the appropriate set of economic circumstances, positive economic impacts could result. However, prediction of these impacts was beyond the scope of this economic analysis.

4.5 Management Strategies Needed to Meet 2012 Projected Demand

The alternative water management strategies from SCTRWPG needed to meet the predicted supply shortfall under the proposed Edwards Aquifer pumping limit alternatives were selected by the EDSIMR model on the basis of highest benefit to cost relationship, the location of the shortfall and the amount of water available in the strategy.

Each pumping limit scenario required a separate run of the EDSIMR model. Therefore, the management strategies selected and associated with each pumping limit provide an optimum model solution for that pumping limit alternative. The management strategies selected by EDSIMR are presented in Table 4-11.

Table 4-11 Alternative Water Management Strategy use under alternative Edwards Aquifer pumping limits, 2012 predicted.

Management Strategy	(Available Supply**	Annual Pumping Limit (1, 000 acre-feet per year)		
		400 (Alternatives 1 & 3)	340 (Critical Period Base* for Alternatives 1 & 3	175 (Alternative 2)
L10 MUN	*44,669*	3,350	36,700	44,630
L10 IRR	*40,340*	39,720	38,980	38,720
L15	*40,486*	29,190	40,490	40,490
CZ10c	*16,000*	0	0	16,000
Sctn6a	*28,000*	0	590	28,000
SAWS	*19,826*	0	0	0
Sctn16	*94,500*	0	0	67,210
G15c	*10,500*	0	0	2,160
Sctn3c	*55,000*	0	0	0
L18a	*13,451*	0	0	0
CZ10d	*900*	0	0	0
TOTAL	*363,672*	72,260	116,760	237,210

Source: Appendix A and EDSIMR model predictions.

* A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

** This column represents total available supply. Under no pumping limit, none of the alternative water management strategies are used.

It is estimated that a total of 363,672 acre-feet per year would be available from all strategies recommended for the Edwards Aquifer region. Under the 400,000 acre-feet per year pumping limit alternative, supplies equaling 72,260 acre-feet would be required to replace the reduction in Edwards Aquifer withdrawals for the year 2012. The water shortage would be made up from municipal and irrigation conservation (L10 Municipal and L10 Irrigation) and from the transfer of Edwards Aquifer irrigation rights from the Central and Eastern Regions to municipal use (L15). These strategies provide the least expensive water of all the management strategies to meet the shortfall. None of these strategies are used to their capacity to meet the 400,000 acre-feet per year limit (Table 4-11).

Under the 340,000 acre-feet per year pumping limit, a total of 116,760 acre-feet of water would be needed from alternative sources in 2012 to meet the shortfall in supply. The same three strategies would be utilized under the 340,000 acre-feet pumping limit with each one more nearly approaching its capacity. In addition, strategy SCTN-6A would be developed to provide 590 acre-feet out of a total annual supply capacity of 28,000 acre-feet.

With an annual limit of 175,000 acre-feet, all but four of the management strategies must be used to meet demand. A total of 237,210 acre-feet per year of new water supply would need to be developed from seven of the SCTRWP management strategies identified at the time of this analysis (Table 4-11).

4.6 Regional Economic Impacts Related to Irrigated Crop Reduction

No alternative agricultural land uses in the EAA study area return as much gross or net revenue per acre to farmers as irrigated crops (TAEX). Hence, as limits are imposed, and irrigation water is transferred to municipal and industrial uses, several negative impacts on the regional economy may be expected. Secondary, regional economic impacts in this economic analysis include employment, labor income and gross regional product (the value of goods and services produced in the region) related to reductions in irrigated crop production.

The reduction in irrigated acreage and water use would cause farmers to adjust by switching land use from irrigated production to dryland alternatives. In the Central and Eastern Regions, dryland crop production may be an alternative for some farmers. In the Western Region, more limited rainfall during the growing season for crops means that dryland crops are not likely to be a feasible alternative. Land that is currently used for irrigated crops would likely be converted into livestock production.

Owners of irrigation water permits would be able to sell their rights to other users or to the Authority in retirement agreements. Even though they may receive a payment for water that is more or less equal to the net income earned from use of the same water in irrigated crop production, the two alternatives are likely to have markedly different impacts on the HCP Planning Area's economy.

Receipts for water sales are similar to transfer payments to the permit holder, whether the permit holder is a local farmer, resident landlord or absentee landlord. These sales would preclude the continued use of the land for irrigated crop production. The revenue received from the sale of water rights does not support the chain of economic activity that is required to produce an equal amount of revenue from irrigated crop production.

As irrigated crop production declines, farmers who continue farming by shifting resources to dryland farming would suffer a loss of income since all dryland crop and livestock alternatives would be less profitable. Moreover, other businesses in the area that are dependent upon the irrigated crops sector would suffer a loss in the demand for their goods and services. Most directly affected would be irrigation equipment suppliers, machinery and equipment dealers, banks and financial institutions, as well as cotton ginners, grain elevators and other first-stage processing businesses. In turn, these impacts would further affect businesses that provide consumer goods and services. Economic impacts on these businesses are sometimes referred to as "third-party" impacts (Jones, 1999).

EDSIMR and IMPLAN were used conjointly in the economic impact analysis to estimate the regional second or third party impacts that would follow the reduction in irrigation water use and acreage as a result of the implementation of the pumping limits under the HCP alternatives. These impacts are expressed in terms of labor employment, labor income and gross regional product. These estimates are presented in Tables 4-12 through 4-14.

Table 4-12 Regional impact (# of jobs) on irrigated agriculture-related employment under alternative pumping limits, 2012 projected.

EAA Region	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Western	4,598	4,576	4,560	1,990
Central	844	623	611	611
Eastern	697	363	345	345
Downstream	16	16	16	16
Total Employment	6,156	5,578	5,533	2,962

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-12 presents the predicted employment impacts under each pumping limit and within each region of the HCP Planning Area. In the baseline case of no pumping limits, it is predicted that 6,156 area jobs would be dependent on irrigated crop production in 2012. This number of jobs would include farm workers required on irrigated farms directly, as well as workers indirectly required in related businesses that provide input and services to irrigated farms.

For the Western Region, the prediction of 4,598 jobs is significantly higher than the Texas Workforce Commission's (TWC) reported agricultural employment of 1,203 that is cited in the EIS (Table 3.6-1). There are two reasons for this difference. First, as indicated in Table 4-12, total employment includes employment in related sectors that depend on irrigated crop farms as a market for their goods and services. Second, the EDSIMR predictions are based on data and estimates of the amount of labor required to perform production and harvesting tasks in producing irrigated crops. Many of the jobs in producing and harvesting irrigated crops are part-time and seasonal. There is no requirement that the employment of these workers be reported to the TWC. Hence, the number of jobs predicted in this analysis exceeds that reported by the TWC.

Under the 400,000 and 340,000 acre-feet per year limits, the number of jobs in the HCP Planning Area would fall to just over 5,500 from 6,156 with no limit, a loss of about 11 percent of the total jobs supported by irrigated agriculture without the pumping limits (Table 4-12).

In the Western Region, where most of the agricultural labor is employed, the impacts at these two alternative pumping limits would be slight. As was seen in the previous section, acreage in irrigation would change little under these limits. Irrigated crop production is predicted to continue at about the baseline level of output.

Although total employment related to irrigated crops in the Eastern Region is not large, the greatest relative impact would occur at the 400,000 and 340,000 acre-feet per year limits. Irrigation related employment in this region would fall by one-half from 697 jobs to 350 jobs under these two alternatives (Table 4-12).

The 175,000 acre-feet per year pumping limit is predicted to have significant employment impacts on the irrigated crop and related agribusiness industry within the HCP Planning Area. Total irrigated agriculture related jobs would fall to 2,962, or less than half the predicted level without pumping limits.

In the Western Region, this impact would be even more significant as the number of jobs would fall to 1,990, which is 43 percent of the predicted number without pumping limits (Table 4-12). This predicted loss of 2,608 jobs in the Western Region is equal to 25 percent of the 10,433 total jobs reported for the region in 1997 by the Texas Workforce Commission (see Table 3.6-1). However, this comparison can be misleading since many lost farm workers' jobs are not included in the TWC employment data. The job loss prediction also includes permanent, full time employees of farms, irrigation equipment suppliers and other businesses closely related to irrigated crops as well as "main street" enterprises including consumer goods and services establishments.

A compounding factor to this employment impact is that many of the lost jobs would be relatively low paying and occupied by persons with limited skills and alternative employment opportunities. In the short run, the increase in unemployment could strain the public welfare facilities and services in the Western Region. Without a substitute industry for irrigated crops to support the economic base of the region, an out-migration of laborers and their families may eventually occur.

4.7 Regional Impacts on Labor and Other Resource Income

Two other indicators of economic impacts on the regional economy of reducing irrigated crops and transferring water to municipal and industrial uses are presented in Tables 4-13 and 4-14. These tables show the predicted labor income and gross regional product (income to all regional resources, including labor, land, capital and management in year 2000 dollars), under HCP pumping limit. Gross regional product is directly comparable to Texas' Gross State Product or the U.S. Gross Domestic Product (GDP). All three estimate the value of goods and services produced in a given year.

Table 4-13 Regional labor income (year 2000 $MM) related to irrigated agriculture under alternative pumping limits, 2012 projected.

HCP Planning Area Subregion	Annual Pumping Limit (1,000 acre-feet per year)			
	Available Supply No Limit (513,000 acre-feet per year)*	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Western	40	40	40	17
Central	9	6	6	6
Eastern	6	3	3	3
Downstream	0	0	0	0
Total Income	55	49	48	26

Source: Appendix A and EDSIMR model predictions.
* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-14 Gross Regional Product (year 2000 $MM) of irrigated agriculture under the HCP alternative pumping limits, 2012 projected.

EAA Subregion	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3	340 (Critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Western	84	84	84	37
Central	18	13	12	12
Eastern	13	7	6	6
Downstream	0	0	0	0
Total	115	104	103	56

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Labor income associated with irrigated crop production is presented in Table 4-13. Without a pumping limit, labor income related either directly or indirectly to irrigated crop production in the HCP Planning Area is predicted to be $55 million in 2012. Seventy three percent of predicted labor income is earned in the Western Region.

Compared to predicted employment of 6,156 (Table 4-12) this indicates a predicted annual average wage of about $8,900 (year 2000 dollars) per worker. This annual wage level reflects the employment characteristics of the agricultural sector in the HCP study area. A significant proportion of farm laborers are seasonal and part time, especially in the large irrigated vegetable industry of the Western Region. These workers would be the first and most directly affected by the cessation of irrigated production in the study area.

Annual pumping limits of 400,000 acre-feet per year and 340,000 acre-feet per year are predicted to have no impact on labor income in the Western Region, but are predicted to have a significant impact in the Central and Eastern Regions. In these regions, irrigated crop related income is predicted to fall by 33 percent and 50 percent, respectively. A more restrictive limit of 175,000 acre-feet per year would reduce irrigated crop related labor income more than 50 percent throughout the HCP Planning Area. The major impact of this pumping limit would be in the Western Region where irrigated agricultural and related income is predicted to fall by $23 million (Table 4-13). This is just over 4 percent of the total personal income reported for the Western Region in 1997 (IMPLAN).

Gross regional product (GRP) is a common economic indicator that shows the income or returns to all resources employed in production in a regional economy, including labor income as presented in Table 4-13. Predicted GRP for 2012 is shown in Table 4-14. The GRP predicted for 2012 in the HCP Planning Area related directly or indirectly to irrigated agricultural production totals $115 million (in year 2000 dollars) with no limits on pumping. The Western Region is responsible for the "lion's share" of irrigated crop related GRP, with $84 million, or almost 75 percent of the HCP Planning Area's GRP.

The impacts of limiting pumping from the Edwards Aquifer are similar to the impacts predicted using the employment and labor income indicators. The 400,000 acre-feet per year and 340,000 acre-feet per year pumping limits are predicted to have only modest impacts on GRP. Under an annual pumping limit of 175,000 acre-feet per year, however, agriculturally related GRP is predicted to fall to less than one-half its predicted level without pumping limits (Table 4-14). As indicated in the employment section above, these income and resource use indicators further support the prediction of significant negative effects on irrigated agriculture industries of the area. These effects are particularly severe in the Western Region where most irrigated agriculture is located.

The regional economy of the HCP Planning Area is large and robust, revolving primarily around the urban economy of San Antonio. Hence, the employment, income and GRP impacts predicted in this analysis do not appear large when gauged against these same variables for the overall regional economy, even under the most restrictive pumping limit. However, this prediction is quite different in the Western Region of the HCP Planning Area.

The 400,000 acre-feet per year pumping limit that the Authority is required by law (SB 1477) to reach by 2008 would have little effect on irrigated acreage or the attendant economic variables of employment and income. Further, the limit of 340,000 acre-feet per year is predicted to cause very little disruption in economic activity. But, the imposition of a limit of 175,000 acre-feet per year would have a highly significant and negative impact on the Western Region economy. Losses to irrigation related employment, income and GRP are predicted to be around 50 percent. This change would affect not only private businesses, but also the local jurisdictions that provide public services such as schooling, health care, and police and fire protection.

4.8 Water Prices to Municipal and Industrial Users

There were two primary indicators of economic impacts on municipal and industrial (M&I) users predicted in this analysis: (1) the higher prices necessary to pay for the costs of alternative water supply management strategies; and (2) the loss of net economic benefits or real income to M&I consumers who must pay higher water prices. It was assumed in the analysis that the M&I water shortages projected by the SCTRWPG would be met by developing alternative water management strategies. Further, it was assumed that M&I consumers would continue to use water at the same per capita rate as in the past. Therefore, there were no predicted losses in municipal and industrial jobs or income, as in the case of irrigated agriculture.

Nevertheless, M&I water users would suffer a loss in real income benefits under the HCP alternatives because they would be forced to divert income from other goods and services to pay for higher priced water. The price of water to municipal and industrial consumers is predicted to rise significantly by 2012 as Edwards Aquifer pumping is limited and more expensive alternative water management strategies must be developed to meet projected demand.

Predicted regional non-agricultural water prices for 2012 without pumping limits are shown in the first column of Table 4-15. Prices are predicted to range from $588 and

$589 per acre-foot in the Western and Central regions to $701 per acre-foot in the Eastern Region.

Water prices would rise steadily as the Edwards Aquifer supply is reduced and water supply from the management strategies are developed. In the Eastern Region, where most of the municipal and industrial consumption occurs, predicted prices would nearly double from $701 per acre-foot with no Edwards Aquifer pumping limit to $1,389 per acre-foot at the 175,000 acre-feet per year annual pumping limit. Prices would more than double in the Western and Central Regions for municipal and industrial users (Table 4-15).

Under the 340,000 acre-feet per year pumping limit, prices are predicted to rise by about 37 percent in the Eastern Region. This translates to an increase in water rates of about $0.80, from $2.15 to $2.95 per 1,000 gallons. This would be a relatively modest increase that would likely be absorbed into the large Eastern Region water market. Increases in M&I prices in the Western and Central Regions are predicted to be similar but slightly higher (Table 4-15).

Table 4-15 Average municipal and industrial water prices ($/acre-foot) for alternative pumping limits, by region, 2012 predicted.

Region	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Western	588	663	844	1,324
Central	589	665	846	1,331
Eastern	701	784	961	1,389

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

There were no changes predicted in water prices for the Downstream Region. Limiting the Edwards Aquifer withdrawals supports springflows at minimum levels that would be higher than those expected with no pumping limits. While this likely would cause more water to run in downstream rivers, there is insufficient information at this time to predict the effective demand for this increased river flow.

4.9 Regional Net Economic Benefits from M&I Water Use

The use of water in industrial plants, commercial businesses, energy generation, households and other M&I uses generates income and net benefits above the cost of water, a common indicator of economic welfare, which may be expressed as annual net benefits to water users. If the cost of water increases because of higher prices for the same end uses, benefits derived from using water decline. The change in benefits is a loss to water consumers, which may alternatively be thought of as a reduction in water consumers' real income.

Predictions of the annual net economic benefits to water consumers under alternative pumping limits are presented in Table 4-16. With no limit on Edwards Aquifer pumping the predicted net economic benefits to M&I users is $970 million in 2012. Most of these benefits would be in the municipal sector, including residential and commercial users. Net benefits would fall under each of the proposed pumping limits as more expensive water management strategies are developed to replace Edwards Aquifer water and the cost of meeting M&I demand rises.

Table 4-16 Regional net economic benefits (year 2000 $MM) from M&I water use under Edwards Aquifer pumping limits, 2012 projected.

	Annual Pumping Limit (1,000 acre-feet per year)			
	513 (No Limit)*	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Municipal	891	890	886	808
Industrial	79	79	77	68
TOTAL	970	969	963	877

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

These changes are relatively minor for the 400,000 acre-feet per year and 340,000 acre-feet per year limits, as annual net benefits would be reduced by less than one percent. Under an annual pumping limit of 175,000 acre-feet, net benefits to M&I water users are predicted to fall to $877 million (in year 2000 dollars), a drop of 10 percent from the level with no pumping limit. This amounts to a loss in real income of $93 million per year for M&I users in the HCP Planning Area. The environmental gain as a result of the lower HCP alternative pumping limits is the amount of water left in the Edwards Aquifer which would be available to support springflow. These amounts are estimated to be an additional 113,000 acre-feet, 173,000 acre-feet and 338,000 acre-feet compared to the amount available for springflow under the predicted no limit pumping level of 513,000 acre-feet in 2012.

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APPENDIX A -- EDSIMR

The Edwards Aquifer Simulation Model River basin version (EDSIMR) was used in this project. EDSIMR was developed under most recent funding from the Texas Higher Educational Coordinating Board through the Advanced Research/Advanced Technology Program and the Texas Agricultural Experiment Station as an expansion of an Edwards Aquifer only model as described in McCarl et al. under funding from the Texas Water Development Board, USDA, the Texas Water Resources Institute, and the Texas Agricultural Experiment Station.

EDSIMR was developed so it could be used to analyze the economic and hydrological implications of cooperative water management alternatives for regional ground and surface waters in the South Central Texas Region including new water supply development. EDSIMR depicts water supply and use of regional ground (in the Edwards Aquifer and other Aquifers along the river systems) and surface waters (in the Guadalupe, Blanco, San Antonio, Nueces, and Frio Rivers). The model considers usage by cities, industries and agriculture, return flow, recharge augmentation, conservation, increased reuse, water development, water rights, water marketing, springflow maintenance, river flows, bay/estuary inflows, Edwards Aquifer elevation levels, and major impoundment management (Corpus Christ, Choke Canyon, Medina, Diversion, and Canyon Lakes). It depicts construction of additional water development projects as identified by the South Central Texas Regional Water Planning Group (SCTRWPG).

EDSIMR operates across a ten-state representation of the probability distribution of recharge and associated precipitation ranging from very dry to very wet years. The probability distribution is an empirical distribution based on the historical recharge of the Edwards Aquifer data for the period 1934 to 1996. The years included, ordered from most dry to most wet, are: 1956 (annual recharge at 43,758 acre-feet), 1951, 1963, 1989, 1952, 1996, 1974, 1976, 1958, and 1987 (annual recharge at 2,003,643 acre-feet). EDSIMR and its predecessor EDSIM have been used to analyze the following:

1) Water development alternatives arising under the regional water planning carried out under Texas Senate Bill 1(Gillig, McCarl, and Boadu 2001.),
2) Alternative configurations for regional water markets under Senate Bill 1477 provisions and alternative springflow limits (McCarl, Keplinger, Dillon, and Williams 1990),
3) A dry year irrigation suspension plan option pursued by the Edwards Aquifer Authority (Keplinger and McCarl 2000; Keplinger, McCarl, Chen, and Ward 1998; Keplinger, McCarl, Chowdhury, and Lacewell 1998),
4) Edwards Aquifer management under alternative recharge and beginning year water level conditions to generate information on economically optimal draw down (Williams, McCarl, and Chen 2001),
5) An EAA directed evaluation of proposed water allocation rules (Wilson, and Associates 2000),
6) A USDA sponsored study of the effects of changes in farm program provisions on Edwards Aquifer water use (Schiable, McCarl, and Lacewell 1999),
7) The usefulness of El Nino Southern Oscillation (ENSO) information in the Edwards Aquifer regional water management process (Chen, Gillig, and McCarl 2001), and The effects of projected climatic change on Edwards Aquifer water management in the context of the US National Climate change assessment (Chen, Gillig, and McCarl 2001; Reilly, Tubiello, McCarl, and Mellillo 2000; and Reilly, et al. 2000).

Theoretical Structure

EDSIMR is a price-endogenous mathematical program composed of about 100,000 continuous variables, and 35,000 constraints in a General Algebraic Modeling System (GAMS) (Brooke, Kendrick, and Meeraus 1992). The objective function maximizes the expected *net* benefits (benefits minus costs) of water use by municipal, industrial, and agricultural sectors. Water use is drawn from regional groundwater or surface water depending upon availability at a particular site. The region is subdivided into east and west for use from the Edwards Aquifer along with 52 river reaches and two other regions for use of non-Edwards Aquifer water. Demand curves are specified for municipal and industrial (M&I) water based on estimates by Griffin and Chang (1991), and Renzetti (1988), and by county with discretionary and non-discretionary uses differentiated in Bexar County (where San Antonio is located). Agricultural use and demand is developed using 65 regional linear programming models defined for particular river reaches or groundwater usage areas which could pursue irrigated and/or dryland crop production.

EDSIMR depicts water on a monthly basis with river flows incorporated in the form of a network flow model depicting flow between river/reservoir reaches which were specified based on data from USGS stream gauges and data provided by HDR Engineering, Inc. (HDR 1991, 1993, and 1999). The river systems are hydrologically connected to the Edwards Aquifer through aquifer recharge, spring discharge, and return flow. Since return flows from agriculture use have been argued to be minor or non-existent (HDR 1991), only return flows from municipal and industrial uses are considered. The rate of return flow is assumed to be 55% and 34% for municipal and industrial use, respectively. This return flow rate is calculated based on 1995 USGS: National Water-Use Data Files as an average across the counties in the region (http://water.usgs.gov/public/watuse/wudata/).

EDSIMR is implemented through the use of a two-stage (Dantzig 1995) or discrete stochastic programming model considering variability in yields and resource usage. The stochastic events are defined by recharge and associated weather/crop yields. Eleven water management options identified by the Habitat Conservative Plan, which are consistent with SCTRWPG, are included in EDSIMR as integer variables (Appendix A). These decisions – whether or not water management strategies should be adopted – are depicted as integer variable choices, build or not build, with annual costs and capacities involved. The amount of water that can be drawn from each water management strategy is limited by its capacity and its corresponding annual cost is considered in the objective function. The model contains constraints on ground/surface water demand and supply availability, agricultural crop mixes, pumping lift formation, possible spring-flow or water use regulations, and non-negativity conditions.

Maximization Procedure

With a set of water management options incorporated, EDSIMR chooses options to maximize net regional economic value. The model is set up under projected 2012 water demand with no pumping limit on the Edwards Aquifer and for each of the proposed HCP alternative limits of 400,000, 340,000, and 175,000 acre-feet per year. Regional economic value is derived from a combination of perfectly elastic demand for agricultural products, agricultural production costs, price elastic municipal demand, price elastic industrial demand, and lift sensitive pumping costs. The municipal demand elasticity is drawn from Griffin and Chang (1991) while the industrial elasticity is obtained from Renzetti (1998). Following Griffin and Chang (1991), the quantity demanded by municipal users depends on rainfall and climatic conditions. The following section presents the specific objective function and constraints.

Objective Function

The objective function maximizes the expected *net* benefits (benefits minus costs) of water use by municipal, industrial, and agricultural sectors. Water use within each sector is drawn from either groundwater or surface water (w). Benefits from using groundwater and surface water in municipal and industrial sectors are determined by the areas under the constant elasticity municipal and industrial demand curves whereas benefits from using groundwater and surface in the agricultural sector are represented by the net agricultural income derived from irrigated and dryland crop production (*CROPPROD*).

Total water costs consist of pumping/diverting costs for the agricultural and non-agricultural sectors and water management plan costs. Fixed costs associated with each water management alternative option (p) incur only if that water management alternative option is adopted (*BUILDPLAN*) whereas variable costs depend on the amount of water used (*NEWWATER*). This objective function is maximized subjected to a set of constraints including ground/surface water demand and supply (both existent and newly developed supplies) balance, agricultural production activities (*c*), hydrologic regressions, nonnegative conditions for decision variables, and binary conditions for water development decisions. The objective function is probabilistically weighted by the state of nature (*r*) or weather conditions ($prob_r$), to reflect the stochastic nature of weather (all variables are typed in upper case and all parameters are typed in lower case.).

$$
\begin{aligned}
\sum_r prob_r \cdot \Big(\sum_c \sum_w & \left(irrincome_{rcw} CROPPROD_{rcw} \right) \\
& + \sum_w \int MUN_{rw} \,\mathrm{dMUN} + \sum_w \int IND_{rw} \,\mathrm{dIND} \\
& - \sum_m \sum_c \sum_w ag\cos t_{cw} * AGWATER_{mrcw} - \sum_w mi\cos t_w * (MUN_{rw} + IND_{rw}) \\
& - \sum_p annualcost_p * \big(\sum_m NEWWATER_{mrp}\big) \Big)
\end{aligned}
$$

Initial Edwards Aquifer Elevation

The initial Edwards Aquifer elevation (*INITIALLEVEL*) measured at J17 and Sabinal well indices is the average of the ending Edwards Aquifer elevation (*ENDLEVEL*) weighted by the probability associated with each state of nature in order to allow the Edwards Aquifer level to fluctuate with the weather.

$$INITIALLEVEL_i = \sum_r \left(prob_r * ENDLEVEL_{ir} \right) \quad \forall \ i = \text{J17 and Sabinal well indices.}$$

Ending Edwards Aquifer Elevation

The ending Edwards Aquifer elevation is a function of the initial elevation, the Edwards Aquifer groundwater use (*EDUSE*), and the Edwards Aquifer recharge (*recharge*). The α_i represents the regression parameter that was previously estimated in the Edwards Aquifer model using the GWSIM-IV Edwards Aquifer Simulation Model.

$$ENDLEVEL_{ir} = \alpha_0 + \alpha_1 recharge_r + \alpha_2 \sum_m EDUSE_{mr} + \alpha_3 INITIALLEVEL_i \qquad \forall\ i \text{ and } r.$$

Spring-flow Regression

Spring-flows (*SPRING*) are generated by a regression which is a function of the initial Edwards Aquifer elevation levels at J17 and Sabinal index wells, the Edwards Aquifer monthly recharge, and the aggregated Edwards Aquifer water use. ω and α represent the regression parameters that were previously estimated in the EDSIMR.

$$SPRING_{imr} = \omega_0 + \omega_i INITIALLEVEL_i + \alpha_1 recharge_{mr} + \alpha_2 EDUSE_{mr} \qquad \forall\ i, m \text{ and } r.$$

Crop Mixes

A crop mix constraint implies that a farmers' crop production decision is a convex combination of crop mix (*CROPMIX*) in which all of the lands used (irrigated or dry land) for a crop grown within a county follows the historical crop mixes (*mixdata*) observed on irrigated and dry land acres by crop and county from the years 1975 to 1996 as well as crop mixes obtained from the 1994 farm program survey indicating what would happen if the farm program was eliminated.

$$CROPPROD_{rcw} = \sum_y \left(mixdata_{ycw} * CROPMIX_{ycw} \right) \qquad \forall\ \text{r}, c \text{ and } w.$$

Irrigated Land

The constraint limits irrigated crop production to irrigated land acres (*land*) available but allows irrigated land acres to be converted to dryland (*TODRY*).

$$\sum_y \sum_c mixdata_{ycw} \cdot CROPMIX_{ycw} = land_w - TODRY_w \qquad \forall\ w.$$

Dryland

This constraint limits dryland acres to those available plus those converted from irrigated acres (sprinkler or furrow).

$$\sum_{y}\sum_{c} mixdata_{ycw} \cdot CROPMIX_{ycw} = land_{w} + TODRY_{w} \qquad \forall\ w.$$

Irrigation Water Demand

The irrigated crop water demand by type of water is also limited to be less than or equal to water available for irrigation by type of water.

$$\sum_{m} watrequire_{mrcw} \cdot CROPPROD_{rcw} \leq \sum_{m} AGWATER_{mrcw} \qquad \forall\ r, c, \text{ and } w.$$

Edwards Aquifer Pumping Balance

The total water demand for agriculture, municipality, and industry using the groundwater pumped from the Edwards Aquifer is limited to be equal to the total amount of the groundwater pumped from the Edwards Aquifer. In general, the amount of water pumped from the Edwards Aquifer (*pump*) is unlimited but is limited to 400,000, 340,000, and 175,000 acre feet per year when the pumping limit is imposed.

$$EDUSE_{mr} = seasonal_{m"mun"} * MUN_{r"ed"} + seasonal_{m"ind"} * IND_{r"ed"} + \sum_{c} AGWATER_{mrc"ed"}$$

$\forall\ m$ and r.

$$MUN_{r"ed"} + IND_{r"ed"} + \sum_{m}\sum_{c} AGWATER_{mrc"ed"} \leq pump_{r} \qquad \forall\ r.$$

Irrigated Water

A water demand and supply balance limits water demand to less than or equal to the total amount of supply available for each water type (*watsupply*).

$$\sum_{m,c} AGWATER_{mrcw} \leq watsupply_{rw} \qquad \forall\ r \text{ and } w.$$

River System

The river system portrays a hydrological relationship among upstream, downstream, as well as in-stream flows, reservoirs/lakes release and spill, diversions, system channel loss, return flow, aquifer recharge, spring-flow, and water transfers where seasonal refers to municipal and industrial monthly seasonal distribution.

$$\begin{aligned} &FLOW_{mr} + seasonal_{m\text{"}mun\text{"}} MUN_{r\text{"}sur\text{"}} + seasonal_{m\text{"}ind\text{"}} IND_{r\text{"}sur\text{"}} + \sum_{c} AGWATER_{mrc\text{"}sur\text{"}} \\ &+ \sum_{upriver} LOSS_{mr} + RECHARGE_{mr} - \sum_{upriver} Flow_{mr} - INFLOW_{mr} - RETURNFLOW_{mr} \\ &- SPRING_{mr} - \sum_{p} NEWWATER_{mrp} \leq 0 \qquad \forall\ m \text{ and } r. \end{aligned}$$

Alternative Water Management Strategies

The decision whether a water management strategy, *p*, should be adopted is viewed as a binary choice, to adopt or not to adopt. If adapted, a water management strategy's variable cost is considered in the objective function. The amount of water that can be drawn from each water management strategy is limited by the capacity of each water management strategy (*capacity*).

$$BUILDPLAN_{p} \in \{0,1\}$$

$$\sum_{m} NEWWATER_{mrp} \leq capacity_{p} * BUILDPLAN_{p} \qquad \forall\ r \text{ and } p.$$

Other Features and Constraints

There are a number of other features and constraints used in the study but not presented in the Appendix. For example, the pumping lift constraint is set as a function of J17 and Sabinal wells ending elevation level. A full description of the model can be found in McCarl et.al.

APPENDIX B -- IMPLAN

Overview of secondary impact issues: Whether the agricultural sector is impacted because of EAA policies, or because of other factors such as market prices and government programs, the effects extend to other economic sectors. As farm businesses sell or lease water rights or otherwise make adjustments in the face of regulations or economic conditions, their actions will affect other businesses in the region from which they buy productive inputs and to which they sell commodities for processing, and may carryover to local governments whose revenues are supported by agricultural activity. These indirect, secondary impacts, whether positive or negative, are sometimes called "third party" effects since the entity being impacted is not directly the subject of the policy that creates the initial impact.

If EAA policies cause farmers to reduce irrigation activity, the effects may include:

1. a reduction in farm labor employment;
2. a reduction in the number of acres leased to farmers who do not own land;
3. a loss of sales of irrigation and other equipment;
4. fewer purchases of seed, fertilizer and pesticides;
5. a reduction in the demand for custom harvesting services;
6. less overall yield of commodities to be processed, stored and transported;
7. a loss of local employment and household income;
8. other losses of business activity related to irrigated agriculture; and
9. a possible reduction in the tax base and loss of tax revenue of counties, schools and municipalities.

Those regions and sectors of the economy that depend wholly or in large part upon agricultural production as a market or a source of throughput would be expected to be most heavily impacted by a rule that limited water withdrawals sufficiently to reduce irrigated agricultural output. Among the specific economic issues for which a rules analysis is required are the impacts of proposed rules on small businesses, on local employment, and community fiscal conditions.

Overview of input-output models: Input-output models are well suited to assessing the secondary economic impacts of the proposed Habitat Conservation Plan (HCP) alternatives. These models provide a means of calculating the "multiplier" effect, e.g. of estimating the extent to which initial changes in one economic sector (such as agriculture) ripple through the economy as changes in sales, income, and employment of resources such labor, capital and management.

Input-output models originated with the Nobel Prize winning work of Leontief (1936), and are structured so as to link sectors of the economy together by identifying the sales and purchases to and from each sector to and from all other sectors, and to and from final demand. Input-output models have been used extensively in the past for forecasting, planning and development, and assessment of policy changes (e.g. Jones, 1997; Tanyeri et al., 1998).

Overview of the IMPLAN model "EAA": IMPLAN is a computer algorithm that can be used to model input-output relationships for any county or group of counties within the United States. It is the most widely used method for developing regional input-output models, and has been applied to the EAA area in previous studies, as indicated by numerous citations at the end of this section. For the assessment of the HCP alternatives, an IMPLAN derived input-output model is developed and entitled "EAA".

IMPLAN uses the most recent local data on employment, income and value of sector outputs, and the National Input-Output Model developed and maintained by the U.S. Department of Commerce. Local, county or regional level equations are estimated starting with the national input-output coefficients and adjusting them for local imports and exports of goods and services using local or regional purchase coefficients (RPCs). RPCs are estimates of the proportion of total good and services purchases made locally within the study region.

IMPLAN contains three important tables (matrices) that are used in the input-output analysis. The Transactions Table is a simultaneous equations system consisting of 528 equations in its least aggregated form. Each equation represents a sector of the economy. These equations detail the sales and purchases of each sector to and from all other sectors within the regional economy as well as sales to sectors external to the region (exports) and sales to final consumers. In the EAA model, the Transaction Table has been aggregated to 32 sectors that include the most water-intensive sectors of the EAA economy. The 32 sectors are:

Code	Sector
EAA01	Dairy farm products
EAA02	Poultry and Eggs
EAA03	Ranch Cattle
EAA04	Feed Lot Livestock
EAA05	Other Livestock
EAA06	Cotton
EAA07	Food Grains
EAA08	Feed Grains
EAA09	Other Field Crops
EAA10	Forestry, Fisheries, Greenhouses
EAA11	Mining
EAA12	Construction
EAA13	Food and Fiber Processing
EAA14	Wood and Paper Processing
EAA15	Printing and Publishing
EAA16	Chemicals
EAA17	Petroleum, Rubber, Leather
EAA18	Non-metallic Mineral Products
EAA19	Primary and Fabricated Metal Products
EAA20	Commercial Machinery, Electronics, Transport
EAA21	Other Manufacturing
EAA22	Transportation, Communication, Non-Water Utilities
EAA23	Water Supply, Sewerage, Sanitary Services
EAA24	Wholesale and Retail Trade
EAA25	Finance, Insurance, Real Estate
EAA26	Business and Social Service
EAA27	Business and Professional Organizations
EAA28	State and Local Government
EAA29	Federal Government
EAA30	Domestic Services
EAA31	Miscellaneous
EAA32	Households

The other two tables are derived through a series of matrix algebra manipulations. The Direct Requirements Table contains a production function for each sector of the economy and shows the amount of purchases that must be made by each sector of the economy from all other sectors in order to produce one dollar of output. The Table of Interdependence Coefficients contains estimates of the total production requirements of all sectors necessary to meet the sale of one dollar to final demand by any given sector. It is from this last table that economic multipliers are derived to trace the effects of a change in one sector to all other sectors. In this assessment, one input-output model is used (EAA) for the entire Edwards aquifer region. Hence, the multipliers show impacts that occur throughout the region regardless of the location of the original, direct economic change.

<u>IMPLAN use in the economic analysis of the HCP alternatives</u>: In the assessment of the economic impacts of the HCP alternatives, IMPLAN is used in conjunction with EDSIMR to estimate the loss of returns to the regional economy due to the unemployment of irrigation resources that may occur from implementation of each the HCP alternatives. The EDSIMR estimates of direct impacts on the irrigated agriculture sector of the economy are entered into IMPLAN to estimate secondary impacts. These impacts occur throughout the regional economy through indirect effects (loss of demand for input supply and processing businesses) and induced effects (loss of demand of businesses that sell products to farm workers and other employees).

Because virtually none of the agricultural commodities produced in the region are processed in the region (beyond initial stage ginning of cotton, storage of grain and packaging of fresh vegetables) the total net change in value of output of each affected crop group can be treated as an export from the region. Hence, the changes introduced into the IMPLAN model are through changes in sales to final demand by each of the agricultural sectors. This estimation used the basic Leontief equations as follows:

$$X = (I-A)^{-1} . Y$$

where: X = a 1 x 32 matrix of total output values for the 31 sectors included in the EAA model

$(I - A)^{-1}$ = the 32 x 32 Leontief interdependence coefficients matrix developed for the EAA-HCP.

Y = a 1 x 32 matrix of sales to find demand by the economic sectors of the EAA study area.

IMPLAN solves this system of matrix equations to obtain multipliers that estimate the secondary impacts that change in one sector of the EAA area (say vegetable production) has on the rest of the regional economy.

These secondary economic impacts are expressed in terms of IMPLAN variables that measure the regional value of business sales, household income, employment and gross regional product (GRP). A reduction in GRP is a measure of the loss of regional benefits from the unemployment of local resources that results from the suspension of irrigated production that may occur with the implementation of EAA-HCP rules. A reduction in water available for agricultural irrigation also reduces the employment of land, capital, labor and management resources in counties where the reductions occur.

IMPLAN thus provides an estimate of impacts on local businesses and employment that includes not only the losses from resource unemployment within irrigated agriculture (direct) but also the secondary losses (indirect and induced) to input suppliers, processors, and other related, third party sectors in the economy. For this initial assessment, the regional economic impacts focus only on the negative impacts of water transfers from irrigated agriculture to other uses. In doing so, several offsetting impacts are ignored. These include; (1) income that may be gained from alternative land uses such as production dryland of crops or livestock and (2) gainful employment of water in production of other goods and services in non-agricultural sectors of the regional economy.

The regional economic impacts presented in the report treat payments to farmers for irrigation rights as a transfer payment from one sector of the economy to landowners' households. As such, the water payments do not generate net secondary impacts within the EAA regional economy as would using that water in producing crops. Payments received for water by landowners is offset by costs to other individuals, businesses or public entities. The net effect is zero for the EAA economy as a whole. Further refinement of this approach is needed to take into account the effects of payments from one County to another and payments going to absentee landowners.

Supplement 1 to Appendix G,

Economic Impacts of Edwards Aquifer Pumping Restriction Alternatives

Tabular Results of Model Output for a 450,000 acre-feet per year Aquifer Pumping Limitation

Submitted to Hicks & Company
For
Edwards Aquifer Habitat Conservation Plan

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Resource Management, Economic Impact Analysis, Environmental Economics

The following tables supplement tables in the report entitled "Economic Impacts of the Edwards Aquifer Pumping Restriction Alternatives." The table numbers correspond to the original table numbers in the report and are identical except for the addition of a column with information for the 450,000 acre-feet/year pumping limit.

Table 4-1 Irrigated crop acreage and acreage shifted to dryland production under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1&3)	340 (Critical Period Base ** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	28,092	25,307	24,820	24,666	12,901
Cotton	6,981	6,137	4,053	3,871	908
Feed Grains	30,415	23,153	13,600	12,651	3,905
Food Grains	15,697	14,358	11,448	11,195	1,915
Oil Seeds	4,307	3,367	2,829	2,781	434
Others	7,762	6,228	3,478	3,222	1,108
All Irrigated Crops	93,254	78,550	60,228	58,386	21,171
Acres Shifted to Dryland Production	0	14,704	33,026	34,868	72,083
All Crops	93,254	93,254	93,254	93,254	93,254

Source: EDSIMR model predictions.
* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-2 Irrigated crop acres and acreage shifted to dryland production in the EAA Western Region under Edwards Aquifer pumping limits, 2012 predicted

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1&3)	340 (Critical Period Base ** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	20,682	20,681	20,681	20,678	8,913
Cotton	3,336	3,336	3,336	3,335	372
Feed Grains	9,844	9,843	9,844	9,844	1,099
Food Grains	10,446	10,445	10,446	10,446	1,165
Oil Seeds	2,643	2,643	2,643	2,643	295
Others	2,381	2,381	2,381	2,380	265
All Irrigated Crops	49,332	49,329	49,331	49,326	12,109
Acres Shifted to Dryland Production	0	0	0	0	37,223
All Crops	49,332	49,329	49,331	49,326	49,332

Source: EDSIMR model predictions.
* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-3 Irrigated crop acres and acreage shifted to dryland production in the EAA Central Region under Edwards Aquifer pumping limits, 2012 predicted

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	2,895	2,267	2,267	2,267	2,267
Cotton	3,643	2,798	716	534	534
Feed Grains	15,730	12,089	3,089	2,306	2,306
Food Grains	5,039	3,909	999	746	746
Oil Seeds	1,366	722	185	139	139
Others	4,655	3,613	924	690	690
All Irrigated Crops	33,328	25,398	8,180	6,682	6,682
Acres Shifted to Dryland Production	0	7,930	25,148	26,646	26,646
All Crops	33,328	33,328	33,328	33,328	33,328

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-4 Irrigated crop acreage and acreage shifted to dryland production in the EAA Eastern region under Edwards Aquifer pumping limits, 2012 projected.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1&3)	340 (Critical Period Base ** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	4,516	2,359	1,872	1,721	1,721
Cotton	0	0	0	0	0
Feed Grains	4,774	1,151	600	433	433
Food Grains	209	0	0	0	0
Oil Seeds	298	0	0	0	0
Others	621	130	68	47	47
All Irrigated Crops	10,418	3,640	2,540	2,201	2,201
Acres Shifted to Dryland Production	-	6,778	7,878	8,217	8,217
All Crops	10,418	10,418	10,418	10,418	10,418

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-5 Irrigated crop acres and acreage shifting to dryland production in the EAA Downstream Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1, 000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Vegetables	0	0	0	0	0
Cotton	0	0	1	1	1
Feed Grains	67	67	67	67	67
Food Grains	0	0	3	3	3
Oil Seeds	0	0	0	0	0
Others	104	104	104	104	104
All Irrigated Crops	171	171	175	175	175
Acres Shifted to Dryland Production	0	0	0	0	0
All Crops	171	171	175	175	175

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-6 HCP Planning Area water use under alternative Edwards Aquifer pumping limits, 2012 predicted

Water Source: (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Edwards Aquifer	513	445	400	340	175
Current Development	38	38	38	38	38
Future Development	0	51	72	117	237
Existing Surface	98	98	98	98	98
Region Wide Total	649	632	608	593	548

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-7 Annual water use by sector and source in the Western Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source: (1,000 acre-feet)					
Agriculture:					
Edwards Aquifer	42	36	34	29	2
Current Development	0	0	0	0	0
Future Development	0	6	6	6	6
Existing Surface	1	1	1	1	1
Agriculture Total	43	43	41	36	8
Municipal:					
Edwards Aquifer	7	7	5	3	3
Current Development	0	0	0	0	0
Future Development	0	0	2	4	4
Existing Surface	0	0	0	0	0
Municipal Total	7	7	7	7	7
Industrial:					
Edwards Aquifer	1	1	1	1	0
Current Development	0	0	0	0	0
Future Development	0	0	0	0	0
Existing Surface	0	0	0	0	0
Industrial Total	1	1	1	1	0
Total of All Sectors:					
Edwards Aquifer	50	44	40	33	5
Current Development	0	0	0	0	0
Future Development	0	6	8	10	10
Existing Surface	1	1	1	1	1
Western Region Total	51	51	48	43	16

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-8 Annual water use by economic sector and source in the Central region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source (1,000 acre-feet):					
Agriculture					
Edwards Aquifer	31.4	18	0.6	0.0	0.0
Current Development	0.0	0	0.0	0.0	0.0
Future Development	0.0	5	4.7	4.2	4.2
Existing Surface	11.2	12	11.2	11.3	11.3
Agriculture Total	42.5	35	16.5	15.5	15.5
Municipal:					
Edwards Aquifer	7.8	7.0	6.2	4.3	4.1
Current Development	0.0	0	0.0	0.0	0.0
Future Development	0.0	0.8	1.6	3.5	3.7
Existing Surface	0.0	0	0.0	0.0	0.0
Municipal Total	7.8	7.8	7.8	7.8	7.8
Industrial:					
Edwards Aquifer	0.3	0.3	0.2	0.2	0.1
Current Development	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.1	0.1	0.1
Existing Surface	0.0	0	0.0	0.0	0.0
Industrial Total	0.3	0.3	0.3	0.3	0.2
Total of All Sectors:					
Edwards Aquifer	39.5	25.2	7.0	4.4	4.2
Current Development	0.0	0	0.0	0.0	0.0
Future Development	0.0	5.9	17.5	7.8	7.9
Existing Surface	11.2	12	11.2	11.3	11.3
Central Region Total	50.6	43.1	35.7	23.5	23.4

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-9 Annual water use by economic sector and source in the Eastern Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source (1,000 acre-feet):					
Agriculture:					
Edwards Aquifer	11	1.8	0	0	0
Current Development	0	0	0	0	0
Future Development	0	1.4	2	2	2
Existing Surface	15	14.4	15	15	15
Agriculture Total	27	17.6	17	17	17
Municipal:					
Edwards Aquifer	336	300.8	282	241	123
Current Development	37	36.9	37	37	37
Future Development	0	37.7	65	97	216
Existing Surface	0	0.4	0	0	0
Municipal Total	374	375.8	384	376	376
Industrial:					
Edwards Aquifer	76	74.2	71	62	43
Current Development	1	1.5	1	1	1
Future Development	0	0	0	0	2
Existing Surface	0	0	0	0	0
Industrial Total	78	75.7	72	63	47
Total of All Sectors:					
Edwards Aquifer	424	376.8	353	303	166
Current Development	38	38.4	38	38	38
Future Development	0	39.1	67	99	219
Existing Surface	16	14.8	16	16	16
Eastern Region Total	478	469.1	474	456	439

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-10 Water use (in 000 acre/feet) by sector and source in the Downstream Region under alternative Edwards Aquifer Pumping Limits, 2012 projected.

Economic Sector:	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Water Source: (1,000 acre-feet)					
Agriculture:					
Edwards Aquifer	0.0	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0	0.0
Existing Surface	0.2	0.2	0.2	0.2	0.2
Agriculture Total	0.2	0.2	0.2	0.2	0.2
Municipal:					
Edwards Aquifer	0.0	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0	0.0
Existing Surface	17.5	17.5	17.5	17.5	17.5
Municipal Total	17.5	17.5	17.5	17.5	17.5
Industrial:					
Edwards Aquifer	0.0	0.0	0.0	0.0	0.0
Current Development	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.0	0.0
Existing Surface	52.3	52.3	52.3	52.3	52.3
Industrial Total	52.3	52.3	52.3	52.3	52.3
Total of All Sectors:					
Edwards Aquifer	0	0	0	0	0
Current Development	0	0	0	0	0
Future Development	0	0	0	0	0
Existing Surface	70	70	70	70	70
Downstream Region Total	70	70	70	70	70

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-11 Water supply (thousands of acre-feet) from SCTRWP Management Strategies and use under alternative Edwards Aquifer pumping limits, 2012 predicted.

Management Strategy	Annual Pumping Limit (1,000 acre-feet per year				
	Available Supply	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base* for Alternatives 1 & 3	175 (Alternative 2)
L10 MUN	44,669		3,350	36,700	44,630
L10 IRR	40,340	39,000	39,720	38,980	38,720
L15	40,486	12,000	29,190	40,490	40,490
CZ10c	16,000				16,000
Sctn6a	28,000			590	28,000
SAWS	19,826				
Sctn16	94,500				67,210
G15c	10,500				2,160
Sctn3c	55,000				
L18a	13,451				
CZ10d	900				
Total	363,672	51,000	72,260	116,760	237,210

Source: Appendix A and EDSIMR model predictions.

* A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-12 Regional impact (# of jobs) on irrigated agriculture-related employment under alternative pumping limits, 2012 projected.

EAA REGION	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (Available Supply, No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Western	4,598	4,598	4,576	4,560	1,990
Central	844	749	623	611	611
Eastern	697	427	363	345	345
Downstream	16	16	16	16	16
Total Employment	6,156	5,790	5,578	5,533	2,962

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Source: Appendix A and EDSIMR model predictions.

Table 4.13 Regional labor income impacts (year 2000 $MM) related to irrigated agriculture under alternative pumping limits, 2012 projected.

HCP Planning Area Subregion	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (Available Supply No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Western	40	40	40	40	17
Central	9	7.5	6	6	6
Eastern	6	3.7	3	3	3
Downstream	0	0	0	0	0
Total Income	55	51.2	49	48	26

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-14 Impact on Gross Regional Product (year 2000 $MM) of irrigated agriculture under the HCP alternative pumping limits, 2012 projected.

EAA Subregion	Annual Pumping Limit (1,000 acre-feet per year)				
	Available Supply No Limit (513,000 acre-feet per year)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (Critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Western	84	84.3	84	84	37
Central	18	15.8	13	12	12
Eastern	13	7.9	7	6	6
Downstream	0	0	0	0	0
Total	115	108.0	104	103	56

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-15 Average municipal and industrial water prices ($/acre-foot) for alternative pumping limits, by region, 2012 predicted.

	Annual Pumping Limit (1,000 acre-feet per year)				
Region	513 (Available Supply No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3	175 (Alternative 2)
Western	588	621	663	844	1,324
Central	589	621	665	846	1,331
Eastern	701	735	784	961	1,389

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-16 Regional net economic benefits (year 2000 $MM) from M&I water use under Edwards Aquifer pumping limits, 2012 projected.

	Annual Pumping Limit (1,000 acre-feet per year)				
	513 (Available Supply, No Limit)*	450 (All Alternatives)	400 (Alternatives 1 & 3)	340 (critical Period Base** for Alternatives 1 & 3)	175 (Alternative 2)
Municipal	891	891	890	886	808
Industrial	79	79	79	77	68
Total	970	970	969	963	877

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Supplement 2 to Appendix G,

Economic Impacts of Edwards Aquifer Pumping Restriction Alternatives

Tabular Results of Model Output for Pumping Limits Associated with EIS Alternatives 1-4

(Includes Interpolated Values for 420,000 acre-feet per year Pumping Limit)

October 6, 2003

Introduction

The section provides supplemental tables to the report entitled "Economic Impacts of the Edwards Aquifer Pumping Restriction Alternatives" dated March 15, 2001. These supplemental tables are necessary to update the original report to include analysis of additional pumping limits (420,000, and 600,000 acre-feet per year) that were not included in the original scope of work. The latter two pumping limits are associated with EIS/HCP Alternative 4, developed subsequent to the original report. The table numbers correspond to the original table numbers in the report and are identical except for three additional columns, one for each of the three additional pumping limits.

Model output values for the 450,000 acre-feet per year pumping limit were generated using the Edwards Simulation Model (EDSIM) and regional input-output model (IMPLAN) runs to predict changes in economic indicators similar to the original analysis. Values for economic indicators for the 420,000 acre-feet per year pumping limit were generated by interpolation of model output for the other pumping limits. Values for economic indicators for the 600,000 acre-feet per year pumping limit were set equal to the values for the "No Limit" pumping level of 513,000 acre-feet per year, as explained in Section 4.5 of the EIS. The information contained in the original report and in the following supplemental tables provides the background for evaluating impacts of the four EIS/HCP alternatives in the EIS sections on Agriculture and Urban Land Use (Section 4.5), Social Resources (Section 4.6), and Economics (Section 4.7).

The economic impacts evaluated in the original report and in the following supplement are those resulting from the loss of irrigated acreage and crop production, or the need to develop alternative agriculture, municipal, and industrial water supplies to replace Edwards Aquifer supplies no longer available from imposed pumping limits. Economic benefits associated with water users buying, selling, or leasing water rights or benefits associated with preservation of springflow and resulting biological and recreation value of the spring ecosystems were not included in this analysis, but are discussed in the main body of the EIS, Section 4.11, Cumulative and Secondary Impacts.

Table 4-1. Irrigated crop acreage and acreage shifted to dryland production under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513 *	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt. 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Vegetables	28,092	28,092	25,307	24,984	24,820	24,666	12,901
Cotton	6,981	6,981	6,137	4,826	4,053	3,871	908
Feed Grains	30,415	30,415	23,153	17,126	13,600	12,651	3,905
Food Grains	15,697	15,697	14,358	12,528	11,448	11,195	1,915
Oil Seeds	4,307	4,307	3,367	3,029	2,829	2,781	434
Others	7,762	7,762	6,228	4,497	3,478	3,222	1,108
All Irrigated Crops	93,254	93,254	78,550	66,990	60,228	58,386	21,171
Acres Shifted to Dryland Production	0	0	14,704	26,264	33,026	34,868	72,083
All Crops	93,254	93,254	93,254	93,254	93,254	93,254	93,254

Source: EDSIMR model predictions.
* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-2. Irrigated crop acres and acreage shifted to dryland production in the EAA Western Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513 *	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt. 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Vegetables	20,682	20,682	20,681	20,681	20,681	20,678	8,913
Cotton	3,336	3,336	3,336	3,336	3,336	3,335	372
Feed Grains	9,844	9,844	9,843	9,844	9,844	9,844	1,099
Food Grains	10,446	10,446	10,445	10,445	10,446	10,446	1,165
Oil Seeds	2,643	2,643	2,643	2,643	2,643	2,643	295
Others	2,381	2,381	2,381	2,381	2,381	2,380	265
All Irrigated Crops	49,332	49,332	49,329	49,330	49,331	49,326	12,109
Acres Shifted to Dryland Production	0	0	0	0	0	0	37,223
All Crops	49,332	49,332	49,329	49,331	49,331	49,326	49,332

Source: EDSIMR model predictions.
* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.
** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-3. Irrigated crop acres and acreage shifted to dryland production in the EAA Central Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513 *	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt. 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Vegetables	2,895	2,895	2,267	2,267	2,267	2,267	2,267
Cotton	3,643	3,643	2,798	1,488	716	534	534
Feed Grains	15,730	15,730	12,089	6,428	3,089	2,306	2,306
Food Grains	5,039	5,039	3,909	2,078	999	746	746
Oil Seeds	1,366	1,366	722	385	185	139	139
Others	4,655	4,655	3,613	1,922	924	690	690
All Irrigated Crops	33,328	33,328	25,398	14,568	8,180	6,682	6,682
Acres Shifted to Dryland Production	0	0	7,930	18,760	25,148	26,646	26,646
All Crops	33,328	33,328	33,328	33,328	33,328	33,328	33,328

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-4. Irrigated crop acreage and acreage shifted to dryland production in the EAA Eastern region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513 *	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt. 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Vegetables	4,516	4,516	2,359	2,037	1,872	1,721	1,721
Cotton	0	0	0	0	0	0	0
Feed Grains	4,774	4,774	1,151	787	600	433	433
Food Grains	209	209	0	0	0	0	0
Oil Seeds	298	298	0	1	0	0	0
Others	621	621	130	89	68	47	47
All Irrigated Crops	10,418	10,418	3,640	2,915	2,540	2,201	2,201
Acres Shifted to Dryland Production	-	-	6,778	7,503	7,878	8,217	8,217
All Crops	10,418	10,418	10,418	10,418	10,418	10,418	10,418

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-5. Irrigated crop acres and acreage shifting to dryland production in the EAA Downstream Region under Edwards Aquifer pumping limits, 2012 predicted.

Irrigated Crop Acreage	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513 *	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt. 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Vegetables	0	0	0	0	0	0	0
Cotton	0	0	2	2	1	1	1
Feed Grains	67	67	67	67	67	67	67
Food Grains	0	0	4	4	3	3	3
Oil Seeds	0	0	0	0	0	0	0
Others	104	104	105	105	104	104	104
All Irrigated Crops	171	171	178	178	175	175	175
Acres Shifted to Dryland Production	0	0	0	0	0	0	0
All Crops	171	171	178	178	175	175	175

Source: EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-6. HCP Planning Area water use under alternative Edwards Aquifer pumping limits, 2012 predicted.

Management Strategy	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513*	450 Alternatives 1&3	420 (DM/CPMP reduction to 30%) Alt 4	400 Alternatives 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alternative 2
Edwards Aquifer	513	513	445	418	400	340	175
Current Development	38	38	38	38	38	38	38
Future Development	0	0	51	62	72	117	237
Existing Surface	98	98	98	112	98	98	98
Region Wide Total	649	649	632	630	608	593	548

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Management Plan (DM/CPMP) Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-7. Annual water use by sector and source in the Western Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector: Water Source: (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513 *	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Agriculture:							
Edwards Aquifer	42	42	36	35	34	29	2
Current Development	0	0	0	0	0	0	0
Future Development	0	0	6	6	6	6	6
Existing Surface	1	1	1	1	1	1	1
Agriculture Total	43	43	43	42	41	36	9
Municipal:							
Edwards Aquifer	7	7	7	6	5	3	3
Current Development	0	0	0	0	0	0	0
Future Development	0	0	0	1	2	4	4
Existing Surface	0	0	0	0	0	0	0
Municipal Total	7	7	7	7	7	7	7
Industrial:							
Edwards Aquifer	1	1	1	1	1	1	0
Current Development	0	0	0	0	0	0	0
Future Development	0	0	0	0	0	0	0
Existing Surface	0	0	0	0	0	0	0
Industrial Total	1	1	1	1	1	1	0
Total All Sectors:							
Edwards Aquifer	50	50	44	41	40	33	5
Current Development	0	0	0	0	0	0	0
Future Development	0	0	6	7	8	10	10
Existing Surface	1	1	1	1	1	1	1
Western Region Total	51	51	51	49	49	44	16

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-8. Annual water use by economic sector and source in the Central region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector: Water Source: (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513 *	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Agriculture:							
Edwards Aquifer	31.4	31.4	17.9	6.7	0.6	0.0	0.0
Current Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	4.8	4.9	4.7	4.2	4.2
Existing Surface	11.2	11.2	11.2	11.2	11.2	11.3	11.3
Agriculture Total	42.6	42.6	33.9	22.8	16.5	15.5	15.5
Municipal:							
Edwards Aquifer	7.8	7.8	7.7	6.7	6.2	4.3	4.1
Current Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.1	1.1	1.6	3.5	3.7
Existing Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Total	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Industrial:							
Edwards Aquifer	0.3	0.3	0.3	0.2	0.2	0.2	0.1
Current Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Existing Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial Total	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Total All Sectors:							
Edwards Aquifer	39.5	39.5	25.9	13.6	7.0	4.4	4.2
Current Development	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Future Development	0.0	0.0	4.9	6.0	6.4	7.8	7.9
Existing Surface	11.2	11.2	11.2	11.2	11.2	11.3	11.3
Central Region Total	50.7	50.7	42.0	30.8	24.6	23.5	23.4

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-9. Annual water use by economic sector and source in the Eastern Region under alternative Edwards Aquifer pumping limits, 2012 predicted.

Economic Sector: Water Source: (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513 *	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Agriculture:							
Edwards Aquifer	11	11	2	1	0	0	0
Current Development	0	0	0	0	0	0	0
Future Development	0	0	1	2	2	2	2
Existing Surface	15	15	14	15	15	15	15
Agriculture Total	26	26	17	18	17	17	17
Municipal:							
Edwards Aquifer	336	336	300	291	282	241	123
Current Development	37	37	37	37	37	37	37
Future Development	0	0	38	48	56	97	216
Existing Surface	0	0	0	0	0	0	0
Municipal Total	373	373	375	376	375	375	376
Industrial:							
Edwards Aquifer	76	76	74	72	71	62	43
Current Development	1	1	1	1	1	1	1
Future Development	0	0	0	0	0	0	2
Existing Surface	0	0	0	0	0	0	0
Industrial Total	77	77	75	73	72	63	46
Total All Sectors:							
Edwards Aquifer	424	424	376	364	353	303	166
Current Development	38	38	38	38	38	38	38
Future Development	0	0	40	49	57	99	219
Existing Surface	25	25	15	15	16	16	16
Eastern Region Total	487	487	469	466	464	456	439

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-10. Water use (in 000 acre/feet) by sector and source in the Downstream Region under alternative Edwards Aquifer Pumping Limits, 2012 projected.

Economic Sector: Water Source: (1,000 acre-feet)	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513 *	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Agriculture:							
Edwards Aquifer	0	0.0	0.0	0	0.0	0.0	0.0
Current Development	0	0.0	0.0	0	0.0	0.0	0.0
Future Development	0	0.0	0.0	0	0.0	0.0	0.0
Existing Surface	0	0.2	0.2	0	0.2	0.2	0.2
Agriculture Total	0.2	0.2	0.2	0	0.2	0.2	0.2
Municipal:							
Edwards Aquifer	0	0.0	0.0	0	0.0	0.0	0.0
Current Development	0	0.0	0.0	0	0.0	0.0	0.0
Future Development	0	0.0	0.0	0	0.0	0.0	0.0
Existing Surface	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Municipal Total	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Industrial:							
Edwards Aquifer	0	0.0	0.0	0	0.0	0.0	0.0
Current Development	0	0.0	0.0	0	0.0	0.0	0.0
Future Development	0	0.0	0.0	0	0.0	0.0	0.0
Existing Surface	52.3	52.3	52.3	52.5	52.3	52.3	52.3
Industrial Total	52.3	52.3	52.3	52.5	52.3	52.3	52.3
Total All Sectors:							
Edwards Aquifer	0	0	0	0	0	0	0
Current Development	0	0	0	0	0	0	0
Future Development	0	0	0	0	0	0	0
Existing Surface	70	70	70	70	70	70	70
Downstream Region Total	70	70	70	70	70	70	70

Source: EDSIMR predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-11. Water supply (thousands of acre-feet) from SCTRWP Management Strategies and use under alternative Edwards Aquifer pumping limits, 2012 predicted.

Management Strategy	Annual Pumping Limit (1,000 acre-feet per year)						
	Available Supply	600 Alternative 4	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
L10 MUN	44,669	0	0	1,147	3,350	36,700	44,630
L10 IRR	40,340	0	39,000	39,717	39,720	38,980	38,720
L15	40,486	0	12,000	21,613	29,190	40,490	40,490
CZ10c	16,000	0	0	0	0	0	16,000
Sctn6a	28,000	0	0	0	0	590	28,000
SAWS	19,826	0	0	0	0	0	0
Sctn16	94,500	0	0	0	0	0	67,210
G15c	10,500	0	0	0	0	0	2,160
Sctn3c	55,000	0	0	0	0	0	0
L18a	13,451	0	0	0	0	0	0
CZ10d	900	0	0	0	0	0	0
Total	363,672	0	51,000	62,477	72,260	116,760	237,210

Source: Appendix A and EDSIMR model predictions.

* A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-12. Regional impact (# of jobs) on irrigated agriculture-related employment under alternative pumping limits, 2012 projected.

REGION	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513*	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts 1&3)	175 Alt. 2
Western	4,598	4,598	4,598	4,585	4,576	4,560	1,990
Central	844	844	749	670	623	611	611
Eastern	697	697	427	385	363	345	345
Downstream	16	16	16	16	16	16	16
Total Employment	6,155	6,155	5,790	5,656	5,578	5,532	2,962

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Source: Appendix A and EDSIMR model predictions.

Table 4.13. Regional labor income impacts (year 2000 $MM) related to irrigated agriculture under alternative pumping limits, 2012 projected.

REGION	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alternative 4	513*	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Western	40	40	40	40	40	40	17
Central	9	9	7.5	6	6	6	6
Eastern	6	6	3.7	3	3	3	3
Downstream	0	0	0	0	0	0	0
Total Income	55	55	51.2	49	49	49	26

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-14. Impact on Gross Regional Product (year 2000 $MM) of irrigated agriculture under the HCP alternative pumping limits, 2012 projected.

REGION	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513*	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Western	84	84	84.3	84	84	84	37
Central	18	18	15.8	14	13	12	12
Eastern	13	13	7.9	7	7	6	6
Downstream	0	0	0	0	0	0	0
Total	115	115	108.0	105	104	102	55

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Managemnt/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-15. Average municipal and industrial water prices ($/acre-foot) for alternative pumping limits, by region, 2012 predicted.

REGION	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513*	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Western	588	588	621	648	663	844	1,324
Central	589	589	621	649	665	846	1,331
Eastern	701	701	735	764	784	961	1,389

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.

Table 4-16. Regional net economic benefits (year 2000 $MM) from M&I water use under Edwards Aquifer pumping limits, 2012 projected.

	Annual Pumping Limit (1,000 acre-feet per year)						
	600 Alt. 4	513*	450 Alts. 1&3	420 (DM/CPMP reduction to 30%) Alternative 4	400 Alts. 1&3	340 (DM/CPMP Base ** for Alts. 1&3)	175 Alt. 2
Municipal	891	891	891	891	890	886	808
Industrial	79	79	79	79	79	77	68
Total	970	970	970	970	969	963	877

Source: Appendix A and EDSIMR model predictions.

* 2012 water demand from Edwards Aquifer with no limit as predicted by EDSIMR.

** A Demand Management/Critical Period Base of 340,000 acre-feet per year for Alternatives 1 & 3 assumes the Critical Period reduction of 15% is in effect for an entire year.