TR-205
November 2002

Texas Water Resources Institute
make every drop count

Economic and Conservation Evaluation of Capital Renovation Projects: Edinburg Irrigation District Hidalgo County No. 1 – 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal

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Rio Grande Basin Initiative administered by the Texas Water Resources Institute of the Texas A&M University System with funds provided through a federal initiative, "Rio Grande Basin Initiative," administered by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement Numbers 2001-45049-01149 and 2001-34461-10405.

Preface[1]

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law 106-576, entitled "The Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000 (Act)." In that Act, the U.S. Congress authorized water conservation projects for irrigation districts relying on the Rio Grande River for supply of agricultural irrigation, and municipal and industrial water. Several phases of project planning, development, evaluation, prioritization, financing, and fund appropriation are necessary, however, before these projects may be constructed.

Based on language in the Act, the "Guidelines for Preparing and Reviewing Proposals for Water Conservation and Improvement Projects Under Public Law 016-576 (Guidelines)" require three economic measures as part of the Bureau of Reclamation's evaluation of proposed projects:

- Number of acre-feet of water saved per dollar of construction costs;
- Number of British Thermal Units (BTU) of energy saved per dollar of construction costs; and
- Dollars of annual economic savings per dollar of initial construction costs.

South Texas irrigation districts have an extensive system of engineered networks – including 24 major pumping stations and lifts, 800 miles of large water mains and canals, 1,700 miles of pipelines, and 700 miles of laterals that deliver water to agricultural fields and urban areas. Yet, many key components are more than 100 years old, outdated and in need of repair. Texas Agricultural Experiment Station and Texas Cooperative Extension economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the Bureau of Reclamation, and the Texas Water Development Board to perform economic and energy evaluations of the proposed projects.

Proposed capital improvement projects include, among others, (a) meters for monitoring in-system flows and improving management of system operations; (b) lining for open-delivery canals and installing pipelines to reduce leaks, improve flow rates, and increase head at diversion points; and (c) pumping plant replacement.

The economists have developed a spreadsheet model, Rio Grande Irrigation District Economics (RGIDECON©), to facilitate the analyses. The spreadsheet's calculations are attuned to economic and financial principles consistent with capital budgeting procedures — enabling a comparison of projects with different economic lives. As a result, RGIDECON© is capable of providing valuable information for prioritizing projects in the event of funding limitations. Results of the analyses can be compared with economic values of water to conduct cost-benefit analyses. Methodology is also included in the spreadsheet for appraising the economic costs

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1 This information is a reproduction of excerpts from a guest column developed by Ed Rister and Ron Lacewell and edited by Rachel Alexander for the first issue of the Rio Grande Basin Initiative newsletter published in *Rio Grande Basin Initiative Outcomes, 1*(1) (Rister and Lacewell).

associated with energy savings. There are energy savings both from pumping less water forthcoming from reducing leaks and from improving the efficiency of pumping plants.

The economic water and energy savings analyses provide estimates of the economic costs per acre-foot of water savings and per BTU (kwh) of energy savings associated with one to five proposed capital improvement activity(ies) (each referred to as a component). An aggregate assessment is also supplied when two or more activities (i.e., components) comprise a proposed capital improvement project for a single irrigation district. The RGIDECON© model also accommodates "what if" analyses for irrigation districts interested in evaluating additional, non-Act authorized capital improvement investments in their water-delivery infrastructure.

The data required for analyzing the proposed capital improvement projects are assimilated from several sources. Extensive interactions with irrigation district managers and engineers are being used in combination with the Rio Grande Regional Water Planning Group Region M report and other studies to identify the information required for the economic and conservation investigations.

The RGIDECON© model applications will provide the basis for Texas Water Resources Institute reports documenting economic analysis of each authorized irrigation district project. An executive summary of the economic analysis of each authorized project will be provided to the irrigation districts for inclusion in their project report. The project reports will be submitted to the Bureau of Reclamation for evaluation prior to being approved for funding appropriations from Congress.

Subsequent to the noted legislation and approval process developed by the Bureau of Reclamation for evaluating legislation-authorized projects being proposed by Rio Grande Basin Irrigation Districts, the binational North American Development Bank (NADBank) announced the availability of an $80 million Water Conservation Fund for funding irrigation projects on both sides of the U.S.-Mexico border. The NADBank also announced a merging of its board with that of the Border Environment Cooperation Commission (BECC), resulting in the latter assuming a facilitation role in assisting U.S. Irrigation Districts and other entities in applying for and being certified for the $40 million of the funding available on the U.S. side of the border. Similar to their efforts on the legislation-authorized projects, Texas Agricultural Experiment Station and Texas Cooperative Extension economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and NADBank and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas Irrigation Districts to BECC and NADBank.

The U.S. Bureau of Reclamation, in a letter dated July 24, 2002 (Walkoviak), stated that RGIDECON© satisfies the legislation authorizing projects and that the Bureau will use the results for economic and energy evaluation. Subsequently, discussions with NADBank and BECC management indicate these analyses are adequate and acceptable for documenting the sustainability aspects of the Districts' Stage 1 and 2 submissions.

About the Authors

M. Edward Rister
Ronald D. Lacewell
Allen W. Sturdivant
John R. C. Robinson
Michael C. Popp
John R. Ellis

The authors are Rister, Professor and Associate Head, Department of Agricultural Economics, Texas A&M University and Texas Agricultural Experiment Station, College Station, TX.; Lacewell, Professor and Assistant Vice Chancellor, Department of Agricultural Economics, Texas Agricultural Experiment Station and Texas Cooperative Extension, College Station, TX.; Sturdivant, Extension Associate, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.; Robinson, Associate Professor, Department of Agricultural Economics, Texas Cooperative Extension, Agricultural Research and Extension Center, Weslaco, TX.; Popp, Student Technician, Department of Agricultural Economics, Texas Cooperative Extension, College Station, TX.; and Ellis, former Associate Research Scientist, Department of Agricultural Economics, Texas Agricultural Experiment Station, College Station, TX.

Acknowledgments

Many individuals have contributed to the methodology developed for the Rio Grande Basin Irrigation District economic analyses as described herein. We gratefully acknowledge and appreciate the input and assistance of the following:

- ***George Carpenter, Wane Halbert, Sonia Kaniger, Bill Friend, Rick Smith, and Edd Fifer.*** These irrigation district managers have been and are a continual source of information, support, and inspiration as we work to develop an accurate, consistent, logical, efficient, and practical analytical approach for these investigations;

- ***Larry Smith and Al Blair.*** These private consulting engineers have substantiated and extended the insights of the irrigation district managers, thereby strengthening the rigor of our methodology and enhancing the integrity of the data;

- ***Guy Fipps and Eric Leigh.*** These agricultural engineers and our colleagues in the Department of Biological and Agricultural Engineering at Texas A&M University and in the Texas Cooperative Extension have provided an extensive amount of background information, contacts, and wisdom;

- ***Jose Amador and Ari Michelsen.*** These Resident Directors of the Agricultural Research and Extension Centers at Weslaco and El Paso, respectively, have been very supportive in identifying contacts, alerting us to critical issues, and arranging meetings, among other collaboration efforts;

- ***Bob Hamilton and Randy Christopherson.*** These economists affiliated with the Bureau of Reclamation have served as reviewers of our methodology. They have also identified appropriate means of satisfying the data requirements specified in the legislative-mandated Bureau of Reclamation Guidelines for Public Law 106-576 authorizing the projects being analyzed, while also assuring principles of economics and finance are met;

- ***Ron Griffin.*** A Resource Economist in the Department of Agricultural Economics at Texas A&M University, Ron has provided insights regarding relevant resource issues, methods for appraising capital water-related projects, and observations on Texas water issues in general;

- ***John Penson and Danny Klinefelter.*** These agricultural economists specializing in finance in the Department of Agricultural Economics at Texas A&M University have served as mentors through our development of the methodology. They have been an excellent sounding board, reacting to an assortment of questions, ideas, and innovative applications of finance methods;

- ***Larry Walkoviak, Rick Clark, Mike Irlbeck, Thomas Michalewicz, and James Allard.*** These individuals are all affiliated with the U.S. Bureau of Reclamation in various management, engineering, and environmental roles. They have been instrumental in fostering a collaborative environment in which the several agencies involved in this effort can mutually fulfill their varied responsibilities and conduct related activities. They have taken the lead in bringing the Texas Water Development Board into planning and facilitating cooperation across State and Federal agencies;

- ***Danny Fox, Debbie Helstrom, Jeff Walker, and Nick Palacios.*** These engineers and managers with the Texas Water Development Board (TWDB) have provided valuable feedback on the methodology and data, as well as insights on accommodating the requirements imposed by the TWDB on the irrigation districts in association with their receipt and use of State Energy Conservation Office (SECO) funding for the development of their project proposals;

- ***Allan Jones and B. L. Harris.*** As Director and Executive Director of the Texas Water Resources Institute, respectively, they provide leadership and oversight for the Rio Grande Basin Initiative funded through a grant from Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture;

- ***Megan Stubbs.*** An undergraduate in the Department of Agricultural Economics at Texas A&M University, Megan contributed several insightful, thought-provoking comments while reviewing and editing this report and during development of related materials on Rio Grande Basin irrigation districts;

- ***Jason Morris.*** A Student Technician in the Department of Agricultural Economics at Texas A&M University, Jason has provided daily support in the form of computer hardware and software assistance, Internet-based data searches, and other bolstering activities; and

- ***Michele Zinn.*** She is the glue that binds it all together! An Administrative Assistant in the Department of Agricultural Economics and in the Texas Agricultural Experiment Station at Texas A&M University, Michele assists in coordinating daily activities and travel, and provides editorial assistance during manuscript preparation.

Thanks to each and every individual noted above. Nonetheless, we, the authors of this manuscript, accept all responsibilities for any errors, omissions, and/or other oversights that are present in the manuscript and/or the economic spreadsheet model, RGIDECON©.

MER
RDL
AWS
JRCR
MCP
JRE

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Economic and Conservation Evaluation of Capital Renovation Projects: Edinburg Irrigation District Hidalgo County No. 1 – 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal

Abstract

Initial construction costs and net annual changes in operating and maintenance expenses are identified for the capital renovation project proposed by Edinburg Irrigation District Hidalgo County No. 1 to the North American Development Bank (NADBank). Both nominal and real, expected economic and financial costs of water and energy savings are identified throughout the anticipated useful lives for both components of the proposed project (i.e., 72" pipeline replacing a segment of delivery canal along the "Curry Main" and multi-size pipeline replacing a segment of delivery canal along the "North Branch / East Main"). Sensitivity results for both the cost of water savings and cost of energy savings are presented for several important parameters.

Expected cost of water savings and cost of energy savings for both components are aggregated into a composite set of cost measures for the total proposed project. Aggregate cost of water savings is estimated to be **$29.87 per ac-ft** and energy savings are measured at an aggregate value of **$0.0000595 per BTU (i.e., $0.203 per kwh)**.

In addition, expected values are indicated for the Bureau of Reclamation's three principal evaluation measures specified in the United States Public Law 106-576 legislation. The aggregate initial construction cost per ac-ft of water savings measure is $50.90 per ac-ft of water savings. The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0000777 per BTU ($0.265 per kwh). The ratio of initial construction costs per dollar of total annual economic savings is estimated to be -2.01.

Bureau of Reclamation's Endorsement of RGIDECON©

United States Department of the Interior
BUREAU OF RECLAMATION
Great Plains Region
OKLAHOMA - TEXAS AREA OFFICE
300 E. 8th Street, Suite G-169
Austin, Texas 78701-3225

IN REPLY
REFER TO:
TX-Clark
PRJ-8.00

JUL 2 4 2002

Dr. Ron Lacewell
Department of Agricultural Economics
Texas A&M University
College Station, TX 77843-2124

Subject: Economic Model for Use in Preparing Proposals for Water Conservation and Improvement Projects Under Public Law 106-576.

Dear Dr. Lacewell:

Having reviewed the formulas, calculations, and logic which support the "Economic Methodology for South Texas Irrigation Projects" (Model) developed by the Department of Agricultural Economics at Texas A&M University (TAMU), the Bureau of Reclamation (Reclamation) concludes that the Model adequately addresses the specific economic criteria contained in the *Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000* (P. L. 106-576). The results of the Model will fully satisfy the economic and conservation analyses required by the Act and it may be used by any irrigation district or other entity seeking to qualify a project for authorization and/or construction funding under P.L. 106-576.

We express our sincere appreciation to you, your colleagues, and to TAMU for this significant contribution to the efforts to improve the water supply in the Lower Rio Grande Valley.

If we may be of further assistance, please call me at (512) 916-5641.

Sincerely,

M L Martin

for Larry Walkoviak
Area Manager

A Century of Water for the West
1902-2002

Economic and Conservation Evaluation of Capital Renovation Projects: Edinburg Irrigation District Hidalgo County No. 1 – 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal

Executive Summary

Introduction

Recognizing the seriousness of the water crisis in South Texas, the U.S. Congress enacted Public Law 106-576, entitled "The Lower Rio Grande Valley Water Conservation and Improvement Act of 2000." Therein, Congress authorized investigation into four water conservation projects for irrigation districts relying on the Rio Grande River for their municipal, industrial, and agricultural irrigation supply of water. Edinburg Irrigation District Hidalgo County No. 1's (i.e., the District) project is included among the four authorized. Project authorization does not guarantee federal funding as several phases of planning, development, evaluation, etc. are necessary before these projects may be approved for financing and construction.

Subsequent to the noted legislation and approval process developed by the U.S. Bureau of Reclamation for evaluating legislation-authorized projects being proposed by Rio Grande Basin Irrigation Districts, the bi-national North American Development Bank (NADBank) announced the availability of an $80 million Water Conservation Fund for funding irrigation projects on both sides of the U.S.-Mexico border. The NADBank also announced a merging of its board with that of the Border Environment Cooperation Commission (BECC), resulting in the latter assuming a facilitation role in assisting U.S. Irrigation Districts and other entities in applying for and being certified for the $40 million available on the U.S. side of the border. Similar to their efforts on the legislation-authorized projects, Texas Agricultural Experiment Station (TAES) and Texas Cooperative Extension (TCE) economists and engineers are collaborating with Rio Grande Basin irrigation district managers, their consulting engineers, the BECC, and NADBank and using RGIDECON© to develop supportive materials documenting the sustainability of the projects being proposed by Texas Irrigation Districts to BECC and NADBank.

The U.S. Bureau of Reclamation, in a letter dated July 24, 2002, stated that RGIDECON© satisfies the legislation-authorized projects and that the Bureau will use the results for economic and energy evaluation. Subsequently, the BECC has also acknowledged these analyses are adequate and acceptable for the Districts' Stage 1 and 2 submissions.

This report provides documentation of the economic and conservation analysis conducted for the Edinburg Irrigation District Hidalgo County No. 1's project proposal toward its Stage 1 certification with BECC. TAES/TCE agricultural economists have developed this analysis report as facilitated by the Rio Grande Basin Initiative and administered by the Texas Water Resources Institute of the Texas A&M University System[1].

District Description

The District delivers water to approximately 20,000 acres of agricultural cropland and diverts up to 10,409 acre feet (ac-ft) for residential and commercial water users in the city of Edinburg and those areas serviced by the North Alamo Water Supply and Sharyland Water Supply Corporations. Additionally, the District provides up to 42,253 ac-ft to Santa Cruz Irrigation District No. 15. Recent agricultural water use during fiscal years 1998 - 2001 for the District has ranged from 53,792 to 67,661 ac-ft, with the four-year average at 61,804 ac-ft. Municipal and industry (M&I) water use has ranged from 8,741 to 10,466 ac-ft, with the four-year average at 9,515 ac-ft.

Proposed Project Components

The capital improvement project proposed by the District to BECC and NADBank consists of two distinct and non-related components. Specifically, it includes the installation of:

- 5,900 feet of mostly 72" rubber-gasket, reinforced concrete pipeline to replace a segment of concrete-lined delivery canal (of the "Curry Main") – this will reduce seepage losses, improve flow rates, increase head at diversion points; and facilitate greater use of high-technology irrigation systems; and

- 28,600 feet of mostly 60", 54", and 48" rubber-gasket, reinforced concrete pipeline to replace a segment of concrete-lined delivery canal (of the "North Branch / East Main") – this will reduce seepage losses, improve flow rates, reduce relift requirements, increase head at diversion points; and facilitate greater use of high-technology irrigation systems.

Economic and Conservation Analysis Features of RGIDECON©

RGIDECON© is an Excel spreadsheet developed by TAES/TCE economists to investigate the economic and conservation merits of capital renovation projects proposed by Rio Grande Basin Irrigation Districts. RGIDECON© facilitates integration and analysis of information pertaining to proposed projects' costs, productive lives, water and energy savings, and resulting

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[1] This analysis report is based on the best information available at the time and is subject to an array of resource limitations. At times, District management's best educated estimates are used to base cost values well into the future. Obviously, this is imperfect, but given resource limitations, it is believed ample inquiry and review of that information were used to limit the degree of uncertainty.

per unit costs of water and energy savings. RGIDECON© simplifies capital budgeting financial analyses of both individual capital components comprising a project and the overall, total project.

Cost Considerations: Initial & Changes in O&M

Two principal types of costs are analyzed for each component: (a) initial capital outlays and (b) changes in annual operating and maintenance (O&M) expenses. Results related to each type of expenditure for each component are presented in following sections.[2]

Anticipated Water and Energy Savings

Annual water and energy savings are calculated for each component separately and also as a combined total across both components. Water savings are comprised of and associated with (a) reductions in Rio Grande River diversions, (b) increased head at farm diversion points, (c) reduced seepage losses in canals, and (d) better management of water flow. Energy savings are a consequence of reduced diversions and relift pumping and are comprised of (a) the amount of energy used for pumping and (b) the cost (value) of such energy.

Cost of Water and Energy Savings

The estimated cost per ac-ft of water saved as well as the estimated cost of energy saved as a result of a project component's inception, purchase, installation, and implementation is analyzed to gauge each proposed project component's merit. Results related to each type of cost for each component are presented in following sections, as well as totals across both components.

Project Components

Discussion pertaining to costs (initial and subsequent annual O&M) and savings for both water and energy is presented below for each component (i.e., 72" pipeline and multi-size pipeline replacing delivery canals) comprising the Edinburg Irrigation District Hidalgo County No. 1's NADBank project, and then aggregated across both components. With regards to water and energy savings, areas or sources are first identified, with the subsequent discussion quantifying estimates for those sources.

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2 Due to numerical rounding, values as they appear herein may not reconcile exactly with hand calculations the reader may make. In all instances, RGIDECON values are reported with appropriate rounding-off (as determined by the authors) of values which are in this analysis report.

Component #1: 72" Pipeline (i.e., Curry Main)

Component #1 of the District's proposed NADBank project consists of installing 5,300 feet of 72" rubber-gasket, reinforced concrete pipeline (and 600 feet of 24" and 15" pipe) in a segment of concrete-lined delivery canal. The installation period is projected to take one year with an ensuing expected useful life of 49 years. No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

Initial and O&M Costs

Estimated initial capital investment costs total $1,264,299 ($1,131,440 per mile). Annual increases in O&M expenditures for the new 72" pipeline of $827 are expected. Additionally, reductions in annual O&M expenditures of $13,830 are anticipated for discontinued maintenance associated with the existing concrete-lined canal. Therefore, a net decrease in annual O&M costs of $13,003 per mile is expected (basis 2002).

Anticipated Water and Energy Savings

Both off- and on-farm water savings are predicted to be forthcoming from the 5,900 feet of mostly 72" pipeline with the nominal total being 70,070 ac-ft over the 49-year productive life of this component and the real 2002 total being 29,345 ac-ft. Annual *off-farm* water savings estimates are based on 500 ac-ft savings per mile of canal converted to pipeline. Annual *on-farm* water savings are based on a 15% savings of applicable flood-irrigation water (from reduced percolation due to increased head), and a 25% savings of applicable water used toward assumed increased adoption of high-technology delivery systems (e.g., drip and/or micro-jet). Combined associated energy savings estimates are 33,910,981,766 BTU (9,938,740 kwh) in nominal terms over the 49-year productive life and 14,201,535,869 BTU (4,162,232 kwh) in real 2002 terms. Energy savings are based on reduced diversions at the Rio Grande River.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the 72" pipeline segment is estimated to be $42.87 per ac-ft. This value is obtained by dividing the annuity equivalent of the total net cost stream for water savings from all sources of $58,556 (in 2002 terms) by the annuity equivalent of the total net water savings of 1,366 ac-ft (in 2002 terms). The economic and financial cost of energy savings are estimated at $0.0000974 per BTU ($0.332 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $64,371 (in 2002 terms) by the annuity equivalent of the total net energy savings of 661,084,341 BTU (193,753 kwh) (in 2002 terms).

Component #2: Multi-Size Pipeline (i.e., N. Branch / E. Main)

Component #2 of the District's proposed NADBank project consists of installing 28,600 feet of mostly 60", 54", and 48" rubber-gasket, reinforced concrete pipeline in segments of concrete-lined delivery canal. The installation period is projected to take one year with an ensuing expected useful life of 49 years. No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

Initial and O&M Costs

Estimated initial capital investment costs total $3,748,425 ($692,017 per mile). Annual increases in O&M expenditures of $4,482 ($827 per mile of canal converted to pipeline) are expected. Additionally, reductions in annual O&M expenditures of $74,913 ($13,830 per mile) are anticipated for discontinued maintenance. Therefore, a net decrease in annual O&M costs of $70,431 ($13,003 per mile) (basis 2002) is expected.

Anticipated Capital Recovery

The conversion of open, concrete-lined delivery canals into pipelines provides the potential for the recovery of some land for alternative uses. It is anticipated that in association with this component, 34.09 acres of land will be marketable through ensuing years at a real 2002 value of $511,364. These "capital recovery" dollars are considered as a reduction in the real costs of this component.

Anticipated Water and Energy Savings

Both off- and on-farm water savings are predicted to be forthcoming from the 28,600 feet of multi-size (60", 54", 48") pipeline with the nominal total being 167,181 ac-ft over the 49-year productive life of this component and the real 2002 total being 70,013 ac-ft. Annual *off-farm* water savings estimates are based on a weighted average of 490 ac-ft savings per mile of canal converted to pipeline (i.e., 3.17 miles @ 325 ac-ft/mile/yr, plus 1.25 miles @ 500 ac-ft/mile/yr, plus 1.00 mile @ 1,000 ac-ft/mile/yr). Annual *on-farm* water savings are based on a 25% savings of applicable flood-irrigation water (from reduced percolation due to increased head), and a 25% savings of applicable water used toward assumed increased adoption of high-technology delivery systems (e.g., drip and/or micro-jet). Associated energy savings estimates are 121,101,520,577 BTU (35,492,825 kwh) in nominal terms over the 49-year productive life and 50,715,948,012 BTU (14,863,994 kwh) in real 2002 terms. Energy savings are based on reduced diversions at the Rio Grande River and reduced use of relift pumps within the water-delivery system.

Cost of Water and Energy Savings

The economic and financial cost of water savings forthcoming from the multi-size pipeline (60", 54", 48") component is estimated to be $24.42 per ac-ft. This value is obtained by dividing the annuity equivalent of the total net cost stream for water savings from all sources of $79,574 (in 2002 terms) by the annuity equivalent of the total net water savings of 3,259 ac-ft (in 2002 terms). The economic and financial cost of energy savings are estimated at $0.0000490 per BTU ($0.167 per kwh). This value is obtained by dividing the annuity equivalent of the total net cost stream for energy savings from all sources of $115,560 (in 2002 terms) by the annuity equivalent of the total net energy savings of 2,360,837,546 BTU (691,922 kwh) (in 2002 terms).

Totals Across Both Components

The methodology used in evaluating the economic and conservation potential of the proposed project and the respective individual components accounts for timing of inflows and outflows of funds and the anticipated installation and productive time periods of the investments. The cost measures calculated for the individual components are first converted into 'annuity equivalents,' prior to being aggregated into the comprehensive measures. The 'annuity equivalent' calculations facilitate comparison and aggregation of capital projects with unequal useful lives, effectively serving as development of a common denominator. The finance aspect of the 'annuity equivalent' calculation as it is used in the RGIDECON© analyses is such that it represents an annual cost savings associated with one unit of water (or energy) each year extended indefinitely into the future. Zero salvage values and continual replacement of the respective technologies (i.e., 72" pipeline and multi-size pipeline replacing delivery canals) with similar capital items as their useful life ends are assumed.

Initial and O&M Costs

The total capital investment cost required for both components amount to $5,012,724. Combining these costs with anticipated capital recovery from the sale of land, the projected changes in annual O&M expenditures, and the useful lives of the respective project components results in an annuity equivalent of $138,130 costs per year for water savings associated with the total project. The similar measure for costs of energy savings is $179,931 per year.

Anticipated Water and Energy Savings

Both off- and on-farm water savings are expected from the two components with the nominal total being 237,251 ac-ft over their expected productive lives and the real 2002 total being 99,358 ac-ft. On an average annual basis (or annuity equivalent basis), this amounts to 4,625 ac-ft across the two project components, representing 6.5% of the current average water use by the District. Annual water savings estimates are based on reduced seepage, improved water-delivery system management, and increased on-farm efficiency. Associated energy savings estimates are 155,012,502,343 BTU (45,431,565 kwh) in nominal terms over their lives and 64,917,483,882 BTU (19,026,226 kwh) in real 2002 terms. On an average annual basis (or annuity equivalent basis), this amounts to 3,021,921,887 BTU (885,675 kwh) across the two project components. Combined energy savings are based on reduced diversions at the Rio Grande River and reduced relift pumping in the District's delivery system.

Cost of Water and Energy Savings

The aggregation of the economic and financial costs of water and energy savings for the individual project components into cost measures for the total comprehensive project results in estimates of **$29.87 per ac-ft** cost of water savings and **$0.0000595 per BTU ($0.203 per kwh)** cost of energy savings.

Summary

The following table summarizes key information regarding each of the components of Edinburg Irrigation District, Hidalgo County No. 1's NADBank project, with a more complete discussion provided in the text of the complete report.

Table ES1. Summary of Data and Economic and Conservation Analyses Results for Edinburg Irrigation District Hidalgo County No. 1's NADBank Project, 2002.

	Project Component		
	72" Pipeline Replacing Delivery Canal	60", 54", & 48" Pipeline Replacing Delivery Canal	Aggregate
Initial Investment Cost ($)	$ 1,264,299	$ 3,748,425	$ 5,012,724
Expected Useful Life (years)	49	49	n/a
Net Changes in Annual O&M ($)	($ 13,003)	($ 70,431)	($ 83,434)
Annuity Equiv. of Net Cost Stream – Water Savings ($/yr)	$ 58,556	$ 79,574	$ 138,130
Annuity Equivalent of Water Savings (ac-ft)	1,366	3,259	4,625
Calculated Cost of Water Savings ($/ac-ft)	**$42.87**	**$24.42**	**$29.87**
Annuity Equiv. of Net Cost Stream – Energy Savings ($/yr)	$ 64,371	$ 115,560	$ 179,931
Annuity Equivalent of Energy Savings (BTU)	661,084,341	2,360,837,546	3,021,921,887
Annuity Equivalent of Energy Savings (kwh)	193,753	691,992	885,675
Calculated Cost of Energy Savings ($/BTU)	**$ 0.0000974**	**$ 0.0000490**	**$ 0.0000595**
Calculated Cost of Energy Savings ($/kwh)	**$ 0.332**	**$ 0.167**	**$ 0.203**

Sensitivity Analyses

Sensitivity results for both the costs of water and energy savings are presented within the main text whereby two parameters are varied with all others remaining constant. This permits testing of the stability (or instability) of key input values and shows how sensitive results are to variances in other input factors. Key variables subjected to sensitivity analysis include (a) the amount of reduction in Rio Grande River diversions, (b) the expected useful life of the investment, (c) the initial capital investment cost, (d) the value of BTU savings (i.e., cost of energy), and (e) the amount of energy savings estimated.

Legislative Criteria

United States Public Law 106-576 requires three economic measures be calculated and included as part of the information prepared for the Bureau of Reclamation's (Bureau) evaluation of the proposed projects. According to the Bureau, these measures are more often stated in their inverse mode:

- Dollars of construction cost per ac-ft of water saved;
- Dollars of construction cost per BTU (and kwh) of energy saved; and
- Dollars of construction cost per dollar of annual economic savings.

The noted legislated criteria involve a series of calculations similar to, but different from, those used in developing the cost measures cited in the main body of the full analysis report. Principal differences consist of the legislated criteria not requiring aggregation of the initial capital investment costs with the annual changes in O&M expenditures, but rather entailing separate sets of calculations for each type of costs relative to the anticipated water and energy savings. The approach used in aggregating the legislated criteria results presented in Appendix A into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Only real, present value measures are presented and discussed for the legislated criteria aggregate results, thereby designating all such values in terms of 2002 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values.**

The aggregate initial construction costs per ac-ft of water savings measure is $50.90 per ac-ft of water savings which is higher than the comprehensive economic and financial value of **$29.87 per ac-ft** identified and discussed in the main body of the analysis report. The differences in these values are attributable to the incorporation of both initial capital costs and changes in operating expenses in the latter value, and its treatment of the differences in the useful lives of the respective components of the proposed project.

The aggregate initial construction cost per BTU (kwh) of energy savings measure is $0.0000777 per BTU ($0.265 per kwh). These cost estimates are higher than the **$0.0000595 per BTU ($0.203 per kwh)** comprehensive economic and financial cost estimates identified for reasons similar to those noted above with respect to the estimates for costs of water savings.

The final aggregate legislated criterion of interest is the amount of initial construction costs per dollar of total annual economic savings. The estimate for this ratio measure is -2.01, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $2.01 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real 2002 dollars accrued across the two project components' respective planning periods.

Economic and Conservation Evaluation of Capital Renovation Projects: Edinburg Irrigation District Hidalgo County No. 1 – 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal

Introduction

Edinburg Irrigation District Hidalgo County No. 1 is included among the four irrigation districts authorized for water conservation projects in the Lower Rio Grande Valley Water Resources Conservation and Improvement Act of 2000 (Act), or United States Public Law (PL) 106-576. As stated in the legislation, "If the Secretary determines that ... meet[s] the review criteria and project requirements, as set forth in section 3 [of the Act], the Secretary may conduct or participate in funding engineering work, infrastructure construction, and improvements for the purpose of conserving and transporting raw water through that project" (United States Public Law 106-576). This report provides documentation of an economic and conservation analysis conducted for the two components (i.e., 72" pipeline replacing a segment of delivery canal and multi-size pipeline replacing a segment of delivery canal) comprising the Edinburg Irrigation District Hidalgo County No. 1's (the District) project proposed to the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADBank) during the Fall of 2002.

Irrigation District Description[1]

Twenty-eight irrigation districts exist in the Texas Lower Rio Grande Valley (**Exhibit 1**).[2] The Edinburg Irrigation District Hidalgo County No. 1 office is located in Edinburg, Texas (**Exhibits 2** and **3**). The District boundary covers 38,285 acres of Hidalgo County (**Exhibit 4**). Postal and street addresses are P.O. Box 870, 1904 N. Expressway 281, Edinburg, TX 78540. Telephone contact information is 956/383-3886 and the fax number is 956/383-5593. George Carpenter is the District Manager, with Larry Smith of Melden & Hunt, Inc., Edinburg, TX, serving as the consulting engineer for this project.

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1 The general descriptive information presented for the District was assimilated from several sources, including documents provided by George Carpenter (the District manager), the IDEA web site maintained by Guy Fipps and his staff in the Department of Biological and Agricultural Engineering at Texas A&M University, College Station, Texas, the Project Plan and Environmental Information Summary submissions (Melden and Hunt, Inc 2002a-d) to the Border Environment Cooperation Commission (BECC), the BECC's Project Strategic Plan for Edinburg Irrigation District Hidalgo County No. 1, the Region M Rio Grande Regional Water Planning Group report, and Fipps' Technical Memorandum in the latter report (Fipps 2000).

2 Exhibits and Tables are presented at the end of the report, after the References and the Glossary and before the Appendices.

In addition to residential and commercial accounts, there are numerous agricultural irrigation accounts serviced by the District with the majority of agricultural acreage serviced under "as-needed" individual water orders for vegetable and field crops. Additionally, annual permits for orchards and commercial nurseries that use drip or micro-emitter systems are serviced. Lastly, numerous accounts exist for lawn watering, golf courses, parks, school yards, and ponds.

Irrigated Acreage and Major Crops

The District delivers water to approximately 20,000 acres of agricultural cropland within its district. Furrow irrigation accounts for approximately 70-75% of irrigation deliveries. Special turnout connections are provided, as requested, to the small percentage of district customers utilizing polypipe, gated pipe, etc. Flood irrigation is the norm for orchards, sugarcane, and pastures. The typical crop mix across the District is noted in **Table 1**, which illustrates the relative importance (on an acreage basis) of vegetables, citrus, corn, sugarcane, etc. The crop mix distribution within a particular irrigation district may vary considerably depending on output prices and the relative available local water supplies. In water-short years, sugarcane acreage, although a perennial crop, may "migrate" to districts and/or areas appearing to be water-rich, in a relative sense.

Municipalities Served

The District's priority in diverting water is to first meet the demands of residential and commercial users[3] within the District. To facilitate delivery, the District holds 10,409 acre feet (ac-ft) of water rights for M&I diversions to the city of Edinburg, the North Alamo and Sharyland Water Supply Corporations, and an additional 42,253 ac-ft of water rights for Santa Cruz Irrigation District No. 15 (**Exhibit 5**). After fulfilling municipalities' requirements, needs of agricultural irrigators are addressed.

It is important to note that M&I users are dependent on an adequate water supply to fully charge the District's delivery system, providing "push water" for facilitating delivery of their water from the Rio Grande River to the municipal delivery sites. Without a fully-charged system, due to constrained allocations caused by low reservoir levels, M&I users will be required to purchase and/or lease additional water-rights to facilitate delivery of their water.

Historic Water Use

The most recent four years (i.e., 1998-2001) demonstrate a range of water use in the District (**Table 2**). Agricultural use has ranged from 53,792 to 67,661 ac-ft with an average of 61,804 ac-ft. M&I water use has ranged from 8,741 to 10,466 ac-ft with the average at 9,515 ac-

[3] Hereafter, residential and commercial users are referred to as "M&I" (or Municipal & Industrial); terms more widely used in irrigation district operations.

ft. The average total water diverted within the District during this time period is 71,318 ac-ft with a range from 62,606 to 78,127 ac-ft.

Assessment of Technology and Efficiency Status

The District's pumping plant diverts water from the Rio Grande River near the town of Penitas (**Exhibit 5**). From there, the water flows 14 miles until it reaches the cities of McAllen and Edinburg where the District boundary begins. The pumping plant was built in 1926 and has a typical operating capacity of 450 cfs and a maximum of 600 cfs. More than 92 miles of canal, 109 miles of pipeline, 12 relift pumping stations, and one 500 ac-ft storage reservoir comprise the District's delivery-system infrastructure.

The District has been aggressive in increasing the maximum amount of water deliverable to each turnout while also increasing its overall efficiency by reducing irrigation time requirements. The District has initiated a Geographic Information System (GIS) program for linking a mapping system to a data base, indicating: where water has been ordered; for what types of crops; and various systems necessary to deliver the water. Volumetric pricing in water deliveries has become more acceptable, with approximately 40-50 percent of current agricultural water use volumetrically measured. Producers' use of water-conserving methods and equipment is encouraged (Carpenter).

Water Rights Ownership and Sales

The District holds Certificates of Adjudication No's. 0816-000, 0816-001, 0816-002, and 0816-003. Additional M&I water rights (i.e., Certificates of Adjudication) may belong to the respective municipalities, with the District providing diversion and delivery of the water. Further, users interested in acquiring additional water beyond their available allocations may acquire such water from parties interested in selling or leasing rights. Such purchases and/or leases are subject to a transportation delivery loss charged by the District; that is, purchase or lease of one ac-ft of water from sources inside or outside the District will result in users receiving some amount less than one ac-ft at their diversion point.

Water charges assessed irrigators within the District consist of an annual flat-rate maintenance and operations fee assessment of $18 per irrigated acre (which is paid for by the landowner). An additional $9 per acre per irrigation is assessed (either to the landowner-operator, or tenant-producer), with such irrigations approximated at 0.61 ac-ft per acre. On an ac-ft basis, this equates to a variable charge of $14.75 per acre. Volumetrically-priced irrigation water is priced at $13.50 per ac-ft in the District (Carpenter).

In the event of water supplies exceeding demands within the District, current District policy is to sell annual water supplies, even on long-term agreement, rather than toward a one-time sale of water rights (Carpenter). The District has control over the irrigation water supplies, but the municipal rights holders control and realize any benefits accruing from sale or lease of their rights.

Project Data

As proposed by the District, the capital improvements for this project consist of two distinct and independent components with no anticipated synergies between them. The components of the total project are (1) 72" pipeline replacing a segment of delivery canal and (2) multi-size pipeline replacing a segment of delivery canal. Though referred to as components within this report, they are locally referred to as the "Curry Main Project" and "North Branch / East Main Project," respectively (Carpenter).[4]

Component #1 - 72" Pipeline (i.e., Curry Main)

The "Curry Main" services a 7,500 acre area within the District. Summary data for this component of the District's proposed project, are presented (in **Tables 3** and **5)** with discussion of that data following.

<u>Description</u>

This project component consists of installing 5,900 feet of rubber-gasket, reinforced concrete pipeline adjacent to a segment of the Curry Main (i.e., 5,300 feet of 72" pipe and 600 feet of 24" and 15" pipe, the latter two which will serve as tie-ins)[5]. The Curry Main is a concrete-lined delivery canal (east of Edinburg, TX) which has significant seepage problems. After the concrete pipeline is installed and has effectively replaced the segment of concrete-line canal, the old concrete lining will be removed. Replacing the concrete-lined delivery canal is expected to (**Table 7**):

a) eliminate seepage estimated at 500 ac-ft/mile per year;
b) increase head at farm diversion points and reduce on-farm water usage by an estimated 855 ac-ft per year (caused by faster field irrigation with resulting water savings due to lower percolation loss);
c) increase on-farm efficiencies through increased adoption of drip irrigation and/or micro-jet technology which will save an estimated 75 ac-ft of water per year; and
d) provide several secondary benefits, including reduced travel time and expense of canal operators because more farms can be irrigated simultaneously with the increased head - these benefits are not estimated and included in this report.

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4 Due to numerical rounding, values as they appear herein may not reconcile exactly with hand calculations the reader may make. In all instances, RGIDECON© values are reported with appropriate rounding-off (as determined by the authors) of values which are in this analysis report.

5 Although the project length (5,900') exceeds one mile, the additional footage of 24" and 15" pipe is not expected to provide changes in O&M expenses or water savings. Thus, the component's calculations are based as if the total component length is one mile.

Installation Period

It is anticipated that it will take one year after purchase and project component initiation for the pipeline segment to be installed and fully implemented (**Table 6**). No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

Productive Period

A useful life of 49 years[6] for the 72" pipeline segment is expected and assumed in the baseline analysis (**Table 6**). A shorter useful life is possible, but 49 years is considered reasonable and consistent with engineering expectations (Smith). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 2 of the 50-year planning period.

Projected Costs

Two principal types of costs are important when evaluating this proposed investment: the initial capital outlay and recurring operating and maintenance expenses. Assumptions related to each type of expenditure are presented below.

Initial. Based on discussions with Bureau of Reclamation management, expenses associated with design, engineering, and other preliminary development of this project component's proposal are ignored in the economic analysis prepared for the planning report. Such costs are to be incorporated, however, into the materials associated with the final design phase of this project component.

Capital investment costs for purchasing and installing the 5,900 feet of mostly 72-inch pipeline segment total $1,264,299 in 2002 nominal dollars (**Table 6**) (Smith). Sensitivity analyses on the total amount of all capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project component's inception, thereby avoiding the need to account for inflation in the cost estimate.

Recurring. Annual operating and maintenance (O&M) expenditures associated with the installed segment of 72" pipeline are expected to be different than those presently occurring for the concrete-lined delivery canals. Annual O&M expenditures associated with the affected segment of the canal delivery system are anticipated to be $827 (basis 2002 dollars) (**Table 6**). Except for pipeline right-of-way mowing, any O&M requirements during the first year following installation of the segment are assumed to be covered by warranty (Smith).

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6 Actually, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

Projected Savings

Water. Water savings are reductions in diversions from the Rio Grande River, i.e., how much less water will be used by the District as a result of this project component's installation and utilization? Estimates of such savings are comprised, in this case, of both off-farm and on-farm savings with regards to agricultural (i.e., irrigation) water use only; i.e., no savings related to M&I water use are anticipated.

Off-farm savings are those occurring in the District's canal delivery system as a result of eliminated seepage after the targeted canal segment is replaced with pipeline. Historic ponding test studies in the District by Fipps (2001-2002), in comparable soil series, have documented annual water losses on similar concrete-lined canal segments upwards of 3,384 ac-ft per mile. In this analysis report, however, a more conservative annual estimate of 500 ac-ft per mile is assumed when the affected canal segment is replaced with 72" pipe. Existing estimates of water losses are applicable to canals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as the respective canals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant 500 ac-ft of annual water savings per mile (Smith).

The expected reductions in Rio Grande River diversions affiliated *with off-farm* water use are thus conservatively estimated at 500 acre-ft per mile for the 5,300 feet of 72" pipeline (**Table 7**). Since the remaining project length (of 600 feet) of smaller pipe is not expected to affect water savings, total *off-farm* annual water savings are estimated at 500 ac-ft of water (**Table 7**), with sensitivity analyses performed to examine the effects of this assumption.

On-farm water savings are estimated to be forthcoming from two sources. First, increased head at farm diversion points will allow faster irrigation of fields and result in lower levels of percolation losses (Lewis and Milne). Second, the new pipeline will allow for on-farm efficiencies via increased producer adoption of drip irrigation and/or micro-jet technology. Both sources of savings will reduce the District's diversions from the Rio Grande River.

Lower percolation losses due to increased head are estimated to save 855 ac-ft of agricultural irrigation water per year in the District (**Table 7**). This is based on management's assertion that percolation losses would reduce current agricultural demand by a minimum of 15% on the affected acreage. As mentioned, the "Curry Main" affects 7,500 acres. Adjusting for the acreage expected to adopt drip irrigation and/or micro-jet technology (discussed below) results in 7,125 effective acres. Multiplying this by the per acre diverted water factor of .8 ac-ft (i.e., diverted equivalent of .61 ac-ft delivered) for the District results in 5,700 ac-ft of diverted irrigation water used by the affected acreage. Annual savings associated with the lessened percolation losses are therefore calculated as:

7,500	acres serviced by "Curry Main"
- 375	acres to adopt drip/micro-jet
7,125	effective acres continuing to be flood irrigated
x .80	per acre diverted equivalent of .61 ac-ft delivered
5,700	ac-ft of diverted irrigation water used by affected area
x .15	% estimate of reduced water demand (of current ag irrigation volume)
855	ac-ft of annual water savings due to increased head and less percolation loss.

Increased adoption of drip irrigation and/or micro-jet technology is estimated to save 75 ac-ft of agricultural irrigation water per year in the District (**Table 7**). This is based on management's assertion that increases in head pressure and consistency in water availability would increase producer adoption of drip irrigation and/or micro-jet technology and would subsequently reduce current agriculture demand by a minimum of 25% on the affected acreage. Estimates are 750 acres (of the 7,500 affected by the "Curry Main") are potentially adoptable to drip and/or micro-jet. This analysis assumes only 50% of that 750 acres will convert to the water-saving technology, resulting in an effective 375 acres. Again, multiplying this by the per acre diverted water factor of .8 ac-ft (i.e., diverted equivalent of .61 ac-ft delivered) for the District results in 300 ac-ft of diverted irrigation water used by the affected acreage. Annual savings are therefore calculated as:

7,500	acres serviced by "Curry Main"
- 6,750	acres not adoptable to drip/micro-jet
750	acres potentially adoptable to drip and/or micro-jet
x .50	% estimate of adoption assumed in this analysis (conservative)
375	acres effectively assumed to adopt drip and/or micro-jet in analysis
x .80	per acre diverted equivalent of .61 ac-ft delivered
300	ac-ft of diverted irrigation water used by affected area
x .25	% estimate of reduced water demand (of current ag irrigation volume)
75	ac-ft of annual water savings due to adoption of water-saving technology.

The annual amount of *on-farm* savings in the base analysis is thus 930 ac-ft, i.e., 855 + 75. As with the other estimated water savings, these savings are held constant each year of the pipeline's productive period to provide for a conservative analysis. Combining *off-* and *on-farm* water savings results in 1,430 ac-ft per year (**Table 7**).

Energy. In a general sense, energy savings may occur as a result of less water being pumped at the Rio Grande River diversion site and also because of lower relift pumping requirements at one or more points throughout the canal delivery system. The amount of such energy savings and the associated monetary savings are detailed below. No relift pumping energy savings are associated with this component.

Factors constituting energy savings associated with lessened diversion pumping are twofold: (a) less energy used for pumping and (b) the cost (or value) of such energy. Recent historic records for the District's fiscal years 2000 and 2001 are presented in **Table 4.** The District's pumping lift at their Rio Grande River diversion site is 33 feet. Source of diversion pumping energy is split between 92% of natural gas and 8% of electric power. On average, 483,959 BTU were used to pump each ac-ft of water used. Combining the 483,959 BTU per ac-ft with the anticipated 500 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 241,979,319 BTU (70,920 kwh) (**Table 7**). Assuming the historical average $0.0216 cost per kwh[7], the estimated annual irrigation energy cost savings are $1,535 in 2002 dollars (**Table 7**).

Savings anticipated for the *on-farm* reductions in water use are determined in similar fashion and also appear in **Table 7**. Using the 483,959 BTU per ac-ft and multiplying by the 930 ac-ft of annual on-farm water savings results in additional anticipated annual irrigation energy savings of 450,081,534 BTU (131,911 kwh). Again, assuming the historical average $0.0216 cost per kwh, the estimated annual irrigation *on-farm* energy cost savings are $2,855 (i.e., $2,625 + $230) in 2002 dollars. Combining both the *off-* and *on-farm* water savings results in total anticipated irrigation energy cost savings of 692,060,853 BTU (202,831 kwh) or the equivalent of $4,390 in 2002 dollars. Sensitivity analyses are performed to examine the effects of the assumptions for both the amount of energy used per ac-ft of water pumped and the cost per unit of energy.

<u>Operating and Maintenance</u>. It is estimated that annual expenditures for the O&M of the currently concrete-lined canal segments are $13,830 per mile (Carpenter). Thus, across the total 5,300 feet of currently concrete-lined delivery canal proposed for replacing with 72" pipe, a reduction of $13,830 O&M is anticipated (**Table 6**).

<u>Reclaimed Property</u>. No real property will be reclaimed in association with this project component (**Table 6**). Consequently, there is no realizable cash income to claim as a credit against the costs of this project component.

Component #2 -Multi-Size Pipeline (i.e., N. Branch / E. Main)

The "North Branch / East Main" services a 3,783 acre area within the District. Summary data for this component of the District's proposed project, are presented (in **Tables 3** and **5)** with discussion of that data following.

<u>Description</u>

This project component consists of installing 28,600 feet (or 5.42 miles) of rubber-gasket, reinforced concrete pipeline adjacent to a segment of the North Branch / East Main (i.e., 26,600 feet of 60", 54", and 48" pipe and 2,000 feet of 24" and 15" pipe which will serve as tie-ins). The North Branch / East Main is a concrete-lined delivery canal (east of Edinburg, TX) which has

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7 This estimated value calculated using District information provided by Carpenter. The calculations incorporate recognition of the joint sources of pumping power and the respective costs for each, including the base charge for electric power availability.

significant seepage problems. After the concrete pipeline is installed and has effectively replaced the segment of concrete-line canal, the old concrete lining will be removed. Replacing the concrete-lined delivery canal is expected to (**Table 8**):

a) eliminate seepages estimated by 2,655.3 ac-ft per year (i.e., a weighted-average of 490 ac-ft/mile per year) for three sections, as determined by:
   - 325 ac-ft/mile per year for 3.17 miles,
   - 500 ac-ft/mile per year for 1.25 miles, and
   - 1,000 ac-ft/mile per year for 1.00 miles;

b) increase head at farm diversion points and reduce on-farm water usage by an estimated 636.6 ac-ft per year (caused by faster field irrigation and resulting water savings due to lower percolation loss);

c) increase on-farm efficiencies through increased adoption of drip irrigation and/or micro-jet technology, saving an estimated 120 ac-ft of water per year; and

d) provide several secondary benefits, including reduced travel time and expense of canal operators because more farms can be irrigated simultaneously with the increased head - these benefits are not estimated and included in this report.

Installation Period

It is anticipated that it will take one year after purchase and project component initiation for the pipeline segments to be installed and fully implemented (**Table 6**). No losses of operations or otherwise adverse impacts are anticipated during the installation period since this will occur in the off-season.

Productive Period

A useful life of 49 years[8] for the multi-size pipeline segments is expected and assumed in the baseline analysis (**Table 6**). A shorter useful life is possible, but 49 years is considered reasonable and consistent with engineering expectations (Smith). Sensitivity analyses are utilized to examine the effects of this assumption. The first year of the productive period is assumed to occur during year 2 of the 50-year planning period.

Projected Costs

Two principal types of costs are important when evaluating this proposed investment: the initial capital outlay and recurring operating and maintenance expenses. Assumptions related to each type of expenditure are presented below.

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8 As noted previously, the actual estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

<u>Initial</u>. Based on discussions with Bureau of Reclamation management, expenses associated with design, engineering, and other preliminary development of this project component's proposal are ignored in the economic analysis prepared for the planning report. Such costs are to be incorporated, however, into the materials associated with the final design phase of this project component.

Capital investment costs for purchasing and installing the 28,600 feet of multi-size pipeline total $3,748,425 in 2002 nominal dollars (**Table 6**) (Smith). Sensitivity analyses on the total amount of all capital expenditures are utilized to examine the effects of this assumption. All expenditures are assumed to occur on day one of this project component's inception, thereby avoiding the need to account for inflation in the cost estimate.

<u>Recurring</u>. Annual operating and maintenance (O&M) expenditures associated with the installed segments of multi-size pipeline are expected to be different than those presently occurring for the concrete-lined delivery canals. Annual O&M expenditures associated with the affected segment of the canal delivery system are anticipated to be $827 (basis 2002 dollars) per mile of pipeline, or a total of $4,482 (**Table 6**). Except for pipeline right-of-way mowing, any O&M requirement during the first year following installation of the segment is assumed to be covered by warranty (Smith).

<u>Projected Savings</u>

<u>Water</u>. Water savings are reductions in diversions from the Rio Grande River, i.e., how much less water will be used by the District as a result of this project component's installation and utilization? Estimates of such savings are comprised, in this case, of both off-farm and on-farm savings with regards to agricultural (i.e., irrigation) water use only; i.e., no savings related to M&I water use are anticipated.

Off-farm savings are those occurring in the District's canal delivery system as a result of eliminated seepage after the targeted canal segment is replaced with pipeline. Historic ponding test studies in the District by Fipps (2001-2002), in comparable soil series, have documented annual water losses on similar concrete-lined canal segments upwards of 3,384 ac-ft per mile. In this analysis report, however, a more conservative weighted-average estimate of 490 ac-ft per mile (i.e., 325 ac-ft/mile for 3.17 miles, 500 ac-ft/mile for 1.25 miles, and 1,000 ac-ft/mile for 1 mile) is assumed when the affected canal segments are replaced with multi-size reinforced concrete pipeline. Existing estimates of water losses are applicable to canals in their present state. It is highly likely that additional deterioration and increased water loss and associated O&M expenses should be expected as the respective canals age (Carpenter; Halbert). While estimates of ever-increasing seepage losses over time could be developed, the analysis conservatively maintains a constant weighted-average 490 ac-ft of annual water savings per mile (Carpenter).

The expected reductions in Rio Grande River diversions affiliated with *off-farm* water use are thus conservatively estimated at a weighted average of 490 acre-ft per mile for the 28,600 feet of concrete-lined canal replaced with multi-size pipeline (**Table 8**). Thus, total *off-farm* annual water savings are estimated at 2,655.3 ac-ft of water (**Table 8**), with sensitivity analyses performed to examine the effects of this assumption.

On-farm water savings are estimated to be forthcoming from two sources. First, increased head at farm diversion points will allow for faster irrigation of fields and result in lower levels of percolation losses (Lewis and Milne). Second, the new pipeline will allow for on-farm efficiencies via increased producer adoption of drip irrigation and/or micro-jet technology. Both sources of savings will reduce the District's diversions from the Rio Grand River.

Lower percolation losses due to increased head are estimated to save 636.6 ac-ft of agricultural irrigation water per year in the District (**Table 8**). This is based on management's assertion that percolation losses would reduce current agricultural demand by a minimum of 25% on the affected acreage. As mentioned, the "North Branch / East Main" services 3,783 acres. Adjusting for the acreage expected to adopt drip irrigation and/or micro-jet technology, results in 3,183 effective acres. Multiplying this by the per acre diverted water factor of .8 ac-ft (i.e., diverted equivalent of .61 ac-ft delivered) for the District results in 2,546 ac-ft of diverted irrigation water used by the affected acreage. Annual savings are therefore calculated as:

3,783	acres serviced by "North Branch / East Main"
- 600	acres to adopt drip/micro-jet
3,183	effective acres continuing to be flood irrigated
x .80	per acre diverted equivalent of .61 ac-ft delivered
2,546	ac-ft of diverted irrigation water used by affected area
x .25	% estimate of reduced water demand (of current ag irrigation volume)
636.6	ac-ft of annual water savings due to increased head and less percolation loss.

Increased adoption of drip irrigation and/or micro-jet technology is estimated to save 120 ac-ft of agricultural irrigation water per year in the District (**Table 8**). This is based on management's assertion that increases in head pressure and consistency in water availability would increase producer adoption of drip irrigation and/or micro-jet technology and would subsequently reduce current agriculture demand by a minimum of 25% on the affected acreage. Estimates are only 1,200 acres (of the 3,783 affected by the "North Branch / Main East") are potentially adoptable to drip and/or micro-jet. This analysis assumes 50% of the 1,200 acres will convert to the water-saving technology, resulting in an effective 600 acres. Again, multiplying this by the per acre diverted water factor of .8 ac-ft (i.e., diverted equivalent of .61 ac-ft delivered) for the District results in 480 ac-ft of diverted irrigation water used by the affected acreage. Annual savings are therefore calculated as:

3,783	acres serviced by "North Branch / Main East"
- 2,583	acres not adoptable to drip/micro-jet
1,200	acres potentially adoptable to drip and/or micro-jet
x .50	% estimate of adoption assumed in this analysis (conservative)
600	acres effectively assumed to adopt drip and/or micro-jet in analysis
x .80	per acre diverted equivalent of .61 ac-ft delivered
480	ac-ft of diverted irrigation water used by affected area
x .25	% estimate of reduced water demand (of current ag irrigation volume)
120	ac-ft of annual water savings due to adoption of water-saving technology.

The annual amount of *on-farm* savings in the base analysis is thus 756.6 ac-ft, i.e., 636.6 + 120 (**Table 8**). As with the other estimated water savings, these savings are held constant each year of the pipeline's productive period to provide for a conservative analysis. Combining *off-* and *on-farm* water savings results in 3,411.9 ac-ft per year.

Energy. Energy savings may occur as a result of less water being pumped at the Rio Grande River diversion site and also because of lower relift pumping requirements at one or more points throughout the canal delivery system. The amount of such energy savings and the associated monetary savings are detailed below.

Factors constituting energy savings associated with lessened diversion pumping are twofold: (a) less energy used for pumping and (b) the cost (or value) of such energy. Recent historic records for the District's fiscal years 2000 and 2001 are presented in **Table 4.** On average, 483,959 BTU were used to pump each ac-ft of water used. Combining this with the anticipated 2,655.25 ac-ft of annual *off-farm* water savings results in anticipated annual irrigation energy savings of 1,285,031,174 BTU (376,621 kwh) (**Table 8**). Assuming a $0.0216 cost per kwh (Carpenter), the estimated annual irrigation energy cost savings are $8,151 in 2002 dollars (**Table 8**).

District management estimates 15% of the total water pumped by the District is relifted in the "North Branch / East Main," and that this water will not be relifted once the multi-size pipeline in component #2 has replaced the canal (Carpenter). Thus, additional *off-farm* energy savings will be realized as the relift pumps are bypassed. Using the District's four-year average (1998-2001) of total water pumped of 71,318 ac-ft and multiplying by 15% and an assumed 80% savings[9] results in an estimated 8,558 ac-ft of non-relifted water[10]. Using an energy price estimate of $1.95 per ac-ft (which is based upon the Penitas pumping plant energy costs and the cost relationship to the relift station) and dividing into the cost per BTU at the Penitas pumping

9 The assumption is that there will still be some relift pumping, but only occassionally, i.e., 80% of the relift pumping that now occurs will cease.

10 Eliminating the need to relift water saves energy, but not water; i.e., the same amount of water is still diverted and delivered to users within the District – it is not just relifted. Therefore, energy is saved by not operating the relift pumps.

for 2001 results in an estimated 95,846 BTU per ac-ft relifted. Thus, 8,558 ac-ft multiplied by 95,846 BTU results in an anticipated *off-farm* annual energy savings of 820,265,324 BTU (240,406 kwh). Using the calculated energy cost of $0.0694 per kwh[11] results in $16,691 (in 2002 terms) of additional annual *off-farm* energy cost savings (**Table 8**).

Savings anticipated for the *on-farm* reductions in water use are determined in similar fashion and also appear in **Table 8**. Using the 483,959 BTU per ac-ft and multiplying by the 756.6 ac-ft of annual *on-farm* water savings results in additional anticipated annual irrigation energy savings of 366,163,106 BTU (107,316 kwh). Assuming $0.0216 cost per kwh, the estimated annual irrigation *on-farm* energy cost savings are $2,323 (i.e., $1,954 + $368) in 2002 dollars.

Combining all sources of both the *off-* and *on-farm* water savings results in total anticipated irrigation energy cost savings of 2,471,459,604 BTU (724,343 kwh) or the equivalent of $27,165 in 2002 dollars (**Table 8**). Sensitivity analyses are performed to examine the effects of the assumptions for both the amount of energy used per ac-ft of water pumped and the cost per unit of energy.

Operating and Maintenance. It is estimated that annual expenditures for the O&M of the currently concrete-lined canal segments are $13,830 per mile (Carpenter). Thus, across the total 28,600 feet of currently concrete-lined delivery canal proposed for replacing with multi-size pipe, a reduction of $74,913 O&M is anticipated (**Table 6**).

Reclaimed Property. District management conservatively anticipates 34.09 acres of real property worth $511,364 (in 2002 dollars) will be reclaimed in association with this project component (**Table 6**). This is based on an assumed 75% marketability of affected land at $15,000 per acre (Carpenter). Funds received for the reclaimed property (i.e., sold) are assumed received by the District in a lump-sum value at the project's inception, therefore bypassing the need to estimate property appreciation rates, which would be considered revenue forecasting and external to this 'cost' analysis report. Thus, realizable cash income is claimed as a credit against the costs of this project component in the amount of $511,364.

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11 The $0.0694 per kwh energy cost estimate for within-delivery system relift pumping is higher than the $0.0216 per kwh for diversion pumping at the Rio Grande River because the former relies solely on electric power while the latter depends mostly on natural gas power.

Abbreviated Discussion of Methodology[12]

Texas Agricultural Experiment Station and Texas Cooperative Extension economists have developed an economic spreadsheet model, RGIDECON© (Rio Grande Irrigation District Economics), to facilitate economic and conservation analyses of the capital renovation projects proposed by South Texas irrigation districts. The spreadsheet's calculations are attuned to economic and financial principles consistent with capital budgeting procedures for evaluating projects of different economic lives, thereby "leveling the playing field" and allowing "apples to apples" comparisons across projects. As a result, RGIDECON© also is capable of providing valuable information for implementing a method of prioritization of projects in the event of funding limitations.

The results of a RGIDECON© analysis can be used in comparisons to exogenously-specified economic values of water to easily provide for implications of a cost-benefit analysis. Methodology similar to that presented for water savings also is included in the spreadsheet for appraising the economic costs associated with energy savings (both on a BTU and kwh basis). That is, there are energy savings both from pumping less water forthcoming from reducing leaks and from improving the efficiency of pumping plants.

RGIDECON©'s economic and energy savings analyses provide an estimate of the economic costs per ac-ft of water savings and per BTU (kwh) of energy savings associated with each proposed capital improvement activity (i.e., an individual component). An aggregate assessment is also provided for those proposed projects consisting of two or more activities (i.e., components). Lastly, the RGIDECON© model has been designed to accommodate "what if" analyses for Districts interested in evaluating additional, non-Act authorized capital improvement investments in their water delivery infrastructure.

Public Law 106-576 legislation requires a variation of economic analyses in which the initial construction costs and annual economic savings are used independently in assessing the potential of capital renovations proposed by irrigation districts (Bureau of Reclamation). In addition, all calculations are performed on a nominal rather than real basis (Hamilton).

Detailed results for the economic and financial analyses following the methodology presented in Rister et al. (2002) appear in subsequent sections of the main body of this report. Results for the legislative criteria appear in Appendices A and B.

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12 The publication, "Economic Methodology for South Texas Irrigation Projects – RGIDECON©," Texas Water Resources Institute TR-203 (Rister et al. 2002), provides a more extensive documentation of the methodology employed in conducting the analyses presented in this report. Excerpts from that publication are included in this section; several of the authors of this report are co-authors of TR-203. The methodology documented in Rister et al. 2002 was endorsed in July, 2002, as expressed by Larry Walkoviak, Area Manager of the Oklahoma-Texas Office of the Bureau of Reclamation, "The results of the model will fully satisfy the economic and conservation analyses required by the Act and it may be used by any irrigation district or other entity seeking to qualify a project for authorization and/or construction funding under P.L. 106-576."

Assumed Values for Critical Parameters

This section of the report presents the values assumed for several parameters which are considered critical in their effects on the overall analysis results. This discussion is isolated here to emphasize the importance of these parameters and to highlight the values used.[13]

Discount Rates and Compound Factors

The discount rate used for calculating net present values of the different cost streams represents a firm's required rate of return on capital (i.e., interest) or, as sometimes expressed, an opportunity cost on its capital. The discount rate is generally considered to contain three components: a risk-free component for time preference (i.e., social time value), a risk premium, and an inflation premium (Rister et al. 1999).

One estimate of such a discount rate from the District's perspectives would be the cost at which it can borrow money (Hamilton). Griffin notes, however, that because of the potential federal funding component of the project, it could be appropriate to ignore the risk component of the standard discount rate as that is the usual approach for federal projects. Hamilton notes that the Federal discount rate consists of two elements, time value of money and inflation, but that the rate is routinely used as a real rate, ignoring the inflationary component. After considering those views and interacting with Penson and Klinefelter, Texas A&M University agricultural economists specializing in financing, the 2002 Federal discount rate of 6.125% was adopted for use in discounting all financial streams.

Recognition of the potential for uneven annual flows of water and energy savings associated with different project components and different projects encourages normalizing such flows through calculation of the net present value of water and energy savings. In the absence of complete cost-benefit analysis and the associated valuation of water and energy savings, it is acknowledged that there is no inflationary influence to be accounted for during the discounting process (Klinefelter), i.e., only the time value (t) should be recognized in the discounting process. Accordingly, a lower rate than the 6.125% 2002 Federal discount rate is desired. Consultations with Griffin and Klinefelter contributed to adoption of the 4% rate used by Griffin and Chowdhury for the social time value in these analyses.

As presented in Rister et al. (2002), use of an overall discount rate of 6.125% in conjunction with a 4% social time value and the assumption of a 0% risk premium infers a 2.043269% annual inflation rate. Such an inferred rate is consistent with recent and expected rates of nominal price increases for irrigation construction, O&M, and energy costs (Rister et al. 2002). Thus, a 2.043269% rate is used to compound 2002 nominal dollar cost estimates forward for years in the planning period beyond 2002. Rationale for assuming this rate is based both on

[13] As was the case in the previous "Abbreviated Discussion of Methodology" section, some of the text in this section is a capsulated version of what is presented in Rister et al. (2002).

the mathematical relationship presented above and analyses of several pertinent price index series and discussions with selected professionals.[14]

Pre-Project Annual Water Use by the District

Water availability and use in the District has varied considerably in recent years as a result of water shortages in the Rio Grande Basin. **Table 2** contains the District's historic water use among agricultural irrigation and M&I along with an indication of the total use for each of the four most recent years (1998-2001). Rather than isolate one particular year as the baseline on which to base estimates of future water savings, Bureau of Reclamation, Texas Water Development Board, Texas Agricultural Experiment Station, and Texas Cooperative Service representatives agreed during the summer of 2002 to use the average levels of use during a five-year period as a proxy for the baseline (Clark et al. 2002a). At a subsequent meeting (Clark et al. 2002b), consideration was directed to recognizing, when appropriate, how allocation restrictions in recent years may have adversely affected the five-year average to the extent the values do not adequately represent potential irrigated acreage in future years during the project's planning period. Where an irrigation district has been impacted by allocation restriction(s), a more-lengthy time series of water use is to be used to quantify representative water use.

As discussed in more detail earlier in this report, this District's agricultural irrigation use has averaged 61,804 ac-ft during the designated 4-year period. M&I use averages 9,515 ac-ft. The average total water use within the District during 1998-2001 is 71,318 ac-ft. These values are perceived as appropriate for gauging future use during this project's planning period (Carpenter).

Value of Water Savings per Acre-Foot of Water

The analyses reported in this report focus on identifying the costs per ac-ft of water saved and per BTU and kwh of energy saved. The value of water is ignored in the analysis, essentially stopping short of a complete benefit-cost analysis.[15] The results of this analysis can be used, however, in comparisons to exogenously-specified economic values of water to easily provide for implications of a cost-benefit analysis.

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14 Admittedly, excessive precision of accuracy is implied in this assumed value for the rate of annual cost increases. Such accuracy of future projections is not claimed, however, but rather that this precise number is that which satisfies the multiplicative elements of the overall discount rate calculation discussed in Rister et al. (2002), assuming the noted values for risk and time value.

15 RGIDECON© includes opportunities for the value of agricultural irrigation water and the incremental differential value associated with M&I water to be specified, thereby facilitating comprehensive benefit-cost analyses. For the purposes of this study, however, such values are set at $0.00, thereby meeting the assessment requirements specified in the Public Law 106-576 legislation.

Energy Usage per Acre-Foot of Water

Essential elements of this analysis include calculating the cost of energy savings and also recognizing the value of such savings as a reduction in O&M expenditures when evaluating the cost of water savings associated with the respective project components.[16] Historic average energy usage levels of 483,959 BTU per ac-ft of water pumped by the District for calendar years 2000-2001 are used to estimate energy savings resulting when less water is pumped due to implementation of the proposed project component(s) (**Table 4**). Thus, it is anticipated this amount of energy (i.e., 483,959 BTU) will be saved when diversions from the Rio Grande River are lessened by one ac-ft. Another important assumption is there are 3,412 BTU per kwh (Infoplease.com). This equivalency factor allows for converting the energy savings information into an alternative form for readers of this report.

Value of Energy Savings per BTU/kwh

Similar to the manner in which average values are used to represent physical energy unit savings associated with lessened diversions from the Rio Grande River, average costs of energy are used to transform the expected energy savings into an economic value. Records of recent costs of energy for the District have ranged from $2.63 to $3.54 per ac-ft pumped, with the average of $3.08 per ac-ft pumped used in this analysis report (**Table 4**). Sensitivity analyses are utilized to examine the effects of this assumption.

Economic and Financial Evaluation Results by Component

The economic and financial analysis results forthcoming from an evaluation of the afore-mentioned data using RGIDECON© (Rister et al. 2002) are presented in this section for individual project components. Results aggregated across the two project components (72" pipeline and multi-size pipeline replacing delivery canals) are presented in a subsequent section.

Component #1 - 72" Pipeline (i.e., Curry Main)

The first component evaluated is the replacing of 5,900 feet of rubber-gasket, reinforced concrete pipeline adjacent to a segment of the Curry Main (i.e., 5,300 feet of 72" pipe and 600 feet of 24" and 15" pipe) which is currently concrete-lined delivery canal. Results of the analysis of that component follow (**Table 9**).

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16 "There are interests in identifying mutually-exclusive estimates of the costs per unit of (a) water saved and (b) energy saved for the respective projects and their component(s). 'Mutually-exclusive' refers to each respective estimate being calculated independent of the other. The measures are not intended to be additive ... – they are single measures, representing different perspectives of the proposed projects and their component(s)." (Rister et al. 2002)

Quantities of Water and Energy Savings

Critical values in the analyses are the quantities of water and energy anticipated being saved during the 49-year productive life of the pipelines.[17] On a nominal (i.e., non-discounted) basis, 70,070 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component. Thus, the total nominal water savings anticipated are 70,070 ac-ft over the 49-year productive life of this component (**Table 9**). Using the 4% discount rate previously discussed, those nominal savings translate into 29,345 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 29,345 ac-ft (**Table 9**).

On a nominal (i.e., non-discounted) basis, 33,910,981,766 BTU (9,938,740 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 9**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project component. Using the 4% discount rate previously discussed, those nominal savings translate into 14,201,535,869 BTU (4,162,232 kwh) of real irrigation-related energy savings over the 49-year productive life of this component (**Table 9**).

Cost of Water Saved

One principal gauge of a proposed project component's merit is the estimated cost per ac-ft of water saved as a result of the project component's inception, purchase, installation, and implementation. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #1.

NPV of Net Cost Stream. Accounting for all capital purchase and installation construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the 72" pipeline component of the District's project is $(237,761) (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $907,081 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2002 dollars, of purchasing and installing the 72" pipeline as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is substantially greater than the negative nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced energy use in the lengthy planning period are sufficient to more than offset the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

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17 As noted previously, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 70,070 ac-ft (**Table 9**). The corresponding total real water savings expressed in 2002 water quantities are 29,345 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 9**).

Cost per Acre-Foot of Water Saved. The real net cost estimate of $907,081 correlates with the real water savings projection of 29,345 ac-ft. The estimated cost of saving one ac-ft of water using the 72" pipeline comprising this project component is $42.87 (**Table 9**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2002. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002), this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the 72" pipeline with all of the attributes previously indicated.

Sensitivity Results. The results presented above are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per ac-ft of water saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of reduction in Rio Grande River diversions that will result from the purchase, installation, and implementation of the 72" pipeline in the canal delivery system. Thus, the cost per ac-ft of water-saved sensitivity analyses consist of varying the off-farm water-savings dimension[18] of that factor across a range of 125 to 750 ac-ft (including the baseline 500 ac-ft) per mile of 72" pipeline paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) value of BTU savings (i.e., cost of energy). Results for these three sets of sensitivity analyses are presented in **Tables 10, 11,** and **12**, respectively.

Table 10 reveals a range of $27.16 to $390.78 cost per ac-ft of savings around the baseline estimate of $42.87. These calculated values were derived by varying the reduction in Rio Grande River diversions arising from off-farm water savings per mile of 72" pipeline from as low as 125 ac-ft up to 750 ac-ft about the expected 500 ac-ft and by investigating a range of useful lives of the 72" pipeline down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower off-farm (and the assumed linked on-farm) water savings than the predicted 500 ac-ft per mile also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

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18 On-farm water savings are linked to off-farm water savings within RGIDECON©'s assessment of this component of the proposed project. Thus, as the off-farm water savings associated with the 72" pipeline replacing concrete-lined delivery canal is varied in the sensitivity analyses, the on-farm savings also vary.

Similarly, **Table 11** is a presentation of a range of cost estimates varying from $11.41 to $278.75 per ac-ft of savings around the baseline estimate of $42.87. These calculated values were derived by varying the reduction in Rio Grande River diversions arising from off-farm water savings per mile of 72" pipeline from as low as 125 ac-ft up to 750 ac-ft about the expected 500 ac-ft and by considering variations in the cost of the capital investment in the 72" pipeline varying from $500,000 less than the expected $1,264,299 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $1,264,299 capital costs and/or higher-than-expected water savings contributed to lower cost estimates, while both higher investment costs and/or lower off-farm (and the assumed linked on-farm) water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of water savings accounted for varying both the reduction in Rio Grande River diversions arising from investment in 72" pipeline and the cost of energy. **Table 12** is an illustration of the results of varying those parameters from as low as 125 ac-ft up to 750 ac-ft about the expected 500 ac-ft per mile of off-farm water savings and across a range of $0.0150 to $0.0400 per kwh energy costs about the expected $0.0216 per kwh level. The resulting costs of water savings estimates ranged from a high of $185.55 per ac-ft down to a low of $23.55 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to substantial energy cost savings which substantially offset both the initial capital costs of the 72" pipeline plus the anticipated changes in O&M expenses. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

<u>**Cost of Energy Saved**</u>

Besides the estimated cost per ac-ft of water saved as a result of the 72" pipeline's inception, purchase, installation, and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande River will result as improved water management minimizes over-deliveries and increases head at on-farm delivery sites (thereby reducing on-farm water use). These reduced diversions and reduced use associated with the proposed 72" pipeline's capital renovation result in less water being pumped, translating into energy savings. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #1, 72" pipeline.

<u>**NPV of Net Cost Stream**</u>. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the 72" pipeline component of the District's project is $141,274 (**Table 9**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $997,166 (**Table 9**). This amount represents, across the total 50-year planning period, the total net costs, in 2002 dollars, of purchasing and installing the 72" pipeline as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs and allowing no credits for the water savings.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 33,910,981,766 BTU (9,938,740 kwh) (**Table 9**). The corresponding total real energy savings expressed in 2002 energy quantities are 14,201,535,869 BTU (i.e., 4,162,232 kwh) over the 49-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 9**).

Cost per BTU & kwh Saved. The real net cost estimate of $997,166 correlates with the real energy savings projection of 14,201,535,869 BTU (4,162,232 kwh). The estimated cost of saving one BTU of energy using the 72" pipeline comprising this project component is $0.0000974 ($0.332 per kwh) (**Table 9**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2002. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002), this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the 72" pipeline with all of the attributes previously indicated.

Sensitivity Results. As with the cost of water-savings estimates, the results presented above for energy savings are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per BTU (or kwh) saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) again is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the purchase, installation, and implementation of the 72" pipeline in the canal delivery system. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings per mile of 72" pipeline. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 13** and **14, 15** and **16,** and **17** and **18**, respectively.

Tables 13 and **14** reveal a range of $0.0000649 to $0.0002582 cost per BTU (and $0.221 to $0.880 per kwh) of energy savings around the baseline estimate of $0.0000974 per BTU ($0.332 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the 72" pipeline down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 15** and **16** are a presentation of a range of cost estimates varying from $0.0000324 to $0.0001828 per BTU (and $0.110 to $0.623 per kwh) of energy savings around the baseline estimate of $0.0000974 per BTU ($0.332 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the 72" pipeline varying from $500,000 less than the expected $1,264,299 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $1,264,299 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the expected 483,959 BTU (141.84 kwh) increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in Rio Grande River diversions arising from water savings per mile of 72" pipeline. **Tables 17** and **18** are illustrations of the results of varying those parameters from as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and from as low as 125 ac-ft up to 750 ac-ft about the expected 500 ac-ft off-farm water savings per mile of 72" pipeline. The resulting costs of energy savings estimates ranged from a high of $0.0004869 per BTU ($1.660 per kwh) down to a low of $0.0000433 per BTU ($0.148 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high off-farm (and the assumed linked on-farm) water savings – the two factors combined contribute to substantial energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

Component #2 - Multi-Size Pipeline (i.e., N. Branch / E. Main)

The second component evaluated is the replacing of 28,600 feet of rubber-gasket, reinforced concrete pipeline adjacent to a segment of the North Branch / East Main (26,600 feet of 60", 54", and 48" pipe, and 2,000 feet of 24" and 15" pipe) which is currently concrete-lined canal. Results of the analysis of that component follow (**Table 19**).

Quantities of Water and Energy Savings

Critical values in the analyses are the quantities of water and energy anticipated being saved during the 49-year productive life of the pipeline.[19] On a nominal (i.e., non-discounted) basis, 167,181 ac-ft of irrigation water are projected to be saved; no M&I water savings are expected as a result of this project component. Thus, the total nominal water savings anticipated

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[19] As noted previously, the estimated useful life is 50 years instead of 49 years. RGIDECON© was developed to consider up to a maximum 50-year planning horizon, with the perspectives that projections beyond that length of time are largely discounted and also highly speculative. Allowing for the one-year installation period on the front end reduces to 49 years the time remaining for productive use of the asset during the 50-year planning period allowed within RGIDECON©.

are 167,181 ac-ft over the 49-year productive life of this component (**Table 19**). Using the 4% discount rate previously discussed, those nominal savings translate into 70,013 ac-ft of real irrigation savings and 0.0 ac-ft of real M&I water savings, representing a total real water savings of 70,013 ac-ft (**Table 19**).

On a nominal (i.e., non-discounted) basis, 121,101,520,577 BTU (35,492,825 kwh) of energy savings are projected to be saved in association with the forecast irrigation water savings (**Table 19**). Since there are no M&I-related energy savings, these values represent the total energy savings for this project component. Using the 4% discount rate previously discussed, those nominal savings translate into 50,715,948,012 BTU (14,863,994 kwh) of real irrigation-related energy savings over the 49-year productive life of this component (**Table 19**).

Cost of Water Saved

One principal gauge of a proposed project component's merit is the estimated cost per ac-ft of water saved as a result of the project component's inception, purchase, installation, and implementation. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #2, multi-size pipeline.

NPV of Net Cost Stream. Accounting for all capital purchase and installation construction costs, changes in O&M expenditures, and credits for energy savings, the nominal total cost of the 50-year planning period for the multi-size pipeline component of the District's project is $(5,191,323) (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into present-day, real costs of $1,232,675 (**Table 19**). This amount represents, across the total 50-year planning period, the total net costs, in 2002 dollars, of purchasing and installing the multi-size pipeline as well as payment of the net changes in O&M expenditures. Note that the positive real-value amount of costs is substantially greater than the negative nominal-value amount. This result occurs because in the nominal-value amount, the savings accruing from reduced energy use in the lengthy planning period are sufficient to more than offset the initial investment costs. In the case of the real-value amount, however, the savings occurring during the latter years of the planning period are discounted significantly and thus do not offset as much of the initial investment costs.

NPV of All Water Savings. As detailed above, the total nominal water savings anticipated are 167,181 ac-ft (**Table 19**). The corresponding total real water savings expressed in 2002 water quantities are 70,013 ac-ft, assuming the previously-identified discount rate of 4.00% (**Table 19**).

Cost per Acre-Foot of Water Saved. The real net cost estimate of $1,232,675 correlates with the real water savings projection of 70,013 ac-ft. The estimated cost of saving one ac-ft of water using the multi-size pipeline comprising this project component is $24.42 (**Table 19**). This value can be interpreted as the cost of leasing one ac-ft of water in year 2002. It is not the cost of purchasing the water right of one ac-ft. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002), this value represents the costs per year in present-day dollars of saving one ac-ft of water each year into perpetuity through a continual replacement series of the multi-size pipeline with all of the attributes previously indicated.

Sensitivity Results. The results presented above are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per ac-ft of water saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis is considered to be that pertaining to the amount of reduction in Rio Grande River diversions that will result from the purchase, installation, and implementation of the multi-size pipeline in the canal delivery system. Thus, the cost per ac-ft of water-saved sensitivity analyses consist of varying the off-farm water-savings dimension[20] of that factor across a range of 1,500 to 4,000 ac-ft (including the baseline 2,655 ac-ft) per mile of multi-size pipeline paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) value of BTU savings (i.e., cost of energy). Results for these three sets of sensitivity analyses are presented in **Tables 20, 21,** and **22**, respectively.

Table 20 reveals a range of $14.78 to $98.63 cost per ac-ft of savings around the baseline estimate of $24.42. These calculated values were derived by varying the reduction in Rio Grande River diversions arising from off-farm water savings per mile of multi-size pipeline from as low as 1,500 ac-ft up to 4,000 ac-ft about the expected 2,655 ac-ft and by investigating a range of useful lives of the multi-size pipeline down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower off-farm (and the assumed linked on-farm) water savings than the predicted 2,655 ac-ft per mile also increased cost estimates, and higher-than-expected water savings contributed to lower cost estimates.

Similarly, **Table 21** is a presentation of a range of cost estimates varying from $8.20 to $64.03 per ac-ft of savings around the baseline estimate of $24.42. These calculated values were derived by varying the reduction in Rio Grande River diversions arising from off-farm water savings per mile of multi-size pipeline from as low as 1,500 ac-ft up to 4,000 ac-ft about the expected 2,655 ac-ft and by considering variations in the cost of the capital investment in the multi-size pipeline varying from $500,000 less than the expected $3,748,425 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $3,748,425 capital costs and/or higher-than-expected water savings contributed to lower cost

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20 On-farm water savings are linked to off-farm water savings within RGIDECON©'s assessment of this component of the proposed project. Thus, as the off-farm water savings associated with the multi-size pipeline replacing concrete-lined delivery canals are varied in the sensitivity analyses, the on-farm savings also vary.

estimates, while both higher investment costs and/or lower off-farm (and the assumed linked on-farm) water savings than the predicted amounts increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of water savings accounted for varying both the reduction in Rio Grande River diversions arising from investment in multi-size pipeline and the cost of energy. **Table 22** is an illustration of the results of varying those parameters from as low as 1,500 ac-ft up to 4,000 ac-ft about the expected 2,655 ac-ft per mile off-farm water savings and across a range of $0.0150 to $0.0400 per kwh energy costs about the expected $0.0216 per kwh level.[21] The resulting costs of water savings estimates ranged from a high of $51.49 per ac-ft down to a low of $7.35 per ac-ft. The lower cost results are associated with high water savings and high energy costs – the two factors combined contribute to substantial energy cost savings which substantially offset both the initial capital costs of the multi-size pipeline plus the anticipated changes in O&M expenses. The opposite effect is experienced with low energy usage per ac-ft of water savings and low water savings, i.e., higher costs estimates are calculated for these circumstances.

Cost of Energy Saved

Besides the estimated cost per ac-ft of water saved as a result of the multi-size pipeline's inception, purchase, installation, and implementation, another issue of interest is the cost of energy savings. Reduced water diversions from the Rio Grande River will result as improved water management minimizes over-deliveries and increases head at on-farm delivery sites (thereby reducing on-farm water use). These reduced diversions and reduced use associated with the proposed multi-size pipeline's capital renovation result in less water being pumped, translating into energy savings. Additional energy savings are also projected for this component in association with reduced relift pumping. Both deterministic results based on the expected values for all parameters integrated into the RGIDECON© assessments and sets of sensitivity analyses for several pairs of the data parameters are presented below for component #2, multi-size pipeline.

NPV of Net Cost Stream. Accounting for all capital purchase and installation construction costs, and changes in O&M expenditures, the nominal total cost of the 50-year planning period for the multi-size pipeline component of the District's project is $(2,845,852) (**Table 19**). Using the previously-identified discount rate of 6.125%, these nominal cost dollars translate into a present-day, real cost of $1,790,127 (**Table 19**). This amount represents, across the total 50-year planning period, the total net costs, in 2002 dollars, of purchasing and installing the multi-size pipeline as well as payment of the net changes in O&M expenditures, ignoring the changes in energy costs and allowing no credits for the water savings.

NPV of All Energy Savings. As detailed above, the total nominal energy savings anticipated are 121,101,520,577 BTU (35,492,825 kwh) (**Table 19**). The corresponding total real energy savings expressed in 2002 energy quantities are 50,715,948,012 BTU

21 Energy costs for relift pumping are linked to the energy costs for diversion pumping at the Rio Grande River, facilitating variance of both during these sensitivity analyses.

(i.e., 14,863,994 kwh) over the 49-year productive life of this component, assuming the previously-identified discount rate of 4.00% (**Table 19**).

Cost per BTU & kwh Saved. The real net cost estimate of $1,790,127 correlates with the real energy savings projection of 50,715,948,012 BTU (14,863,994 kwh). The estimated cost of saving one BTU of energy using the multi-size pipeline comprising this project component is $0.0000490 ($0.167 per kwh) (**Table 19**). An interpretation of this value is that it is the cost of saving one BTU (kwh) of energy in year 2002. Following through with the economic and capital budgeting methodology presented in Rister et al. (2002), this value represents the costs per year in present-day dollars of saving one BTU (kwh) of energy into perpetuity through a continual replacement series of the multi-size pipeline with all of the attributes previously indicated.

Sensitivity Results. As with the cost of water-savings estimates, the results presented above for energy savings are predicated on numerous assumed values incorporated into the RGIDECON© analysis. Those assumed values and the logic for their assumed values are presented in prior sections. Here, attention is directed toward varying some of those values across a plausible range of possibilities, thereby seeking to identify the stability/instability of the estimated cost measure (i.e., $ costs per BTU (or kwh) saved) in response to changes in certain key parameters. The two-way Data Table feature of Excel (Walkenbach) again is utilized to accomplish these sensitivity analyses whereby two parameters are varied and all others remain constant at the levels assumed for the baseline analysis.

The most critical assumption made in the baseline analysis in this respect is considered to be that pertaining to the amount of energy savings that will result from the purchase, installation, and implementation of the multi-size pipeline in the canal delivery system. Thus, the cost per BTU (or kwh) of energy-saved sensitivity analyses consists of varying the amount of energy savings across a range of 80.0 percent up to 150.0 percent of the baseline 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings paired with variances in three other fundamental factors: (a) expected useful life of the investment; (b) initial capital investment costs; and (c) off-farm water savings per mile of multi-size pipeline. Results on a BTU and kwh basis for these three sets of sensitivity analyses are presented in **Tables 23** and **24, 25** and **26,** and **27** and **28**, respectively.

Tables 23 and **24** reveal a range of $0.0000326 to $0.0001298 cost per BTU (and $0.111 to $0.443 per kwh) of energy savings around the baseline estimate of $0.0000490 per BTU ($0.167 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by investigating a range of useful lives of the capital investment in the multi-size pipeline down from the expected 49 years to as short as only 10 years. As should be expected, shorter-useful lives than the anticipated 49-year productive life resulted in higher cost estimates, lower energy savings than the predicted 100% of current average usage also increased cost estimates, and higher-than-expected energy savings contributed to lower cost estimates.

Similarly, **Tables 25** and **26** are a presentation of a range of cost estimates varying from $0.0000235 to $0.0000783 per BTU (and $0.080 to $0.267 per kwh) of energy savings around the baseline estimate of $0.0000490 per BTU ($0.167 per kwh). These calculated values were derived by varying the amount of energy used per ac-ft of water savings across a range as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and by considering variations in the cost of the capital investment in the multi-size pipeline varying from $500,000 less than the expected $3,748,425 up to $500,000 more than the expected amount. As should be expected, both lower-than-the-anticipated $3,748,425 capital costs and/or higher-than-expected energy savings contributed to lower cost estimates while both higher investment costs and/or lower energy savings than the 483,959 BTU (141.84 kwh) increased the cost estimates.

The final set of sensitivity analyses conducted for the costs of energy savings accounted for varying both the amount of energy used per ac-ft of water savings and the reduction in Rio Grande River diversions arising from water savings per mile of multi-size pipeline. **Tables 27** and **28** are illustrations of the results of varying those parameters from as low as 80.0% up to 150.0% of the expected 483,959 BTU (141.84 kwh) current average usage per ac-ft of water savings and from as low as 1,500 ac-ft up to 4,000 ac-ft about the expected 2,655 ac-ft off-farm water savings per mile of multi-size pipeline. The resulting costs of energy savings estimates ranged from a high of $0.0000863 per BTU ($0.294 per kwh) down to a low of $0.0000244 per BTU ($0.083 per kwh). The lower cost estimates are associated with high energy usage per ac-ft of water savings and high off-farm (and the assumed linked on-farm) water savings – the two factors combined contribute to substantial energy cost savings. The opposite effect is experienced with low energy usage per ac-ft of water savings and low off-farm water savings, i.e., higher costs estimates are calculated for these circumstances.

Economic and Financial Evaluation Results Aggregated Across Components

According to Bureau of Reclamation management (Shaddix), a comprehensive, aggregated measure is required to assess the overall potential performance of a proposed project consisting of multiple components. That is, projects are to be evaluated in the form submitted by Districts and when two or more components comprise a project, one general measure should be determined to represent the total project. Discussions of such comprehensive measures follow for both the cost of water saved and the cost of energy saved. ***Aggregations of only the baseline cost measures are presented; that is, the various sensitivity analyses previously presented and discussed for each individual project component are not duplicated here.***

Following the methodology documented in Rister et al. (2002), the cost measures calculated for the individual components are expressed in 'annuity equivalents.' The 'annuity equivalent' calculations facilitate comparison and aggregation of capital projects with unequal useful lives, effectively serving as development of a common denominator. The finance aspect of the 'annuity equivalent' calculation as it is used in the RGIDECON© analyses is such that it represents an annual cost savings associated with one unit of water (or energy) each year extended indefinitely into the future. Zero salvage values and continual replacement of the respective technologies (i.e., 72" pipeline and multi-size pipeline replacing delivery canals) with similar capital items as their useful life ends are assumed.

Cost of Water Saved

Table 29 provides aggregated information on the cost of water saved, based on calculated values previously discussed, for the 72" and multi-size pipeline replacing delivery canals components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of water saved is **$29.87 per ac-ft**.

72" Pipeline Replacing Delivery Canal

The initial capital investment associated with the '72" Pipeline' capital renovation is $1,264,299 in 2002 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $907,081 value noted at the top of the '72" Pipeline' column in **Table 29**. The nominal water savings anticipated during the 50-year planning period total 70,070 ac-ft; discounted into a real 2002 value, those savings are estimated to be 29,345 ac-ft (**Table 9**). Converting both of the real 2002 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $58,556 to achieve 1,366 ac-ft of water savings per year (**Table 29**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $42.87 per ac-ft of water savings for the 72" pipeline replacing delivery canals capital renovation (**Table 29**).

Multi-Size Pipeline Replacing Delivery Canal

The initial capital investment associated with the 'Multi-Size Pipeline' capital renovation is $3,748,425 in 2002 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $1,232,675 value noted at the top of the 'Multi-Size Pipeline' column in **Table 29**. The nominal water savings anticipated during the 50-year planning period total 167,181 ac-ft; discounted into a real 2002 value, those savings are estimated to be 70,013 ac-ft (**Table 19**). Converting both of the real 2002 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $79,574 to achieve 3,259 ac-ft of water savings per year (**Table 29**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $24.42 per ac-ft of water savings for the multi-size pipeline replacing delivery canals capital renovation (**Table 29**).

Aggregate Measure of Cost of Water Savings

Combining the costs of the two components (i.e., 72" pipeline and multi-size pipeline replacing delivery canals) of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $2,139,756 which translates into an annuity cost equivalent of $138,130 per year (**Table 29**). The total NPV of water savings is 99,358 ac-ft, representing an annuity equivalent of **4,625 ac-ft of water savings** (**Table 29**). Performing the same math as used in calculating the costs of water savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of water savings) produces the **$29.87 per ac-ft** water savings aggregate cost measure (**Table 29**).

Cost of Energy Saved

Table 30 provides aggregated information on the cost of energy saved, based on calculated values previously discussed, for the 72" and multi-size pipeline replacing delivery canals components. The individual component measures are displayed in the table and then aggregated in the far-right column, indicating that the overall cost of water saved is **$0.0000595 per BTU (or $0.203 per kwh)**.

72" Pipeline Replacing Delivery Canal

The initial capital investment associated with the '24" Pipelines' capital renovation is $1,264,299 in 2002 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $997,166 value noted at the top of the '72" Pipeline' column in **Table 30.** This value is again higher than the corresponding $907,081 value in **Table 29** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved'. The nominal energy savings anticipated during the 50-year planning period total 33,910,98,766 BTU (9,938,740 kwh) (**Table 9**). Discounted into a real 2002 value, those savings are estimated to be 14,201,535,869 BTU (4,162,232 kwh) (**Table 9**). Converting both of the real 2002 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $64,371 to achieve 661,084,341 BTU (193,753 kwh)of energy savings per year (**Table 30**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $0.0000974 per BTU ($0.332 per kwh)of energy savings for the 72" pipeline replacing delivery canal capital renovation (**Table 30**).

Multi-Size Pipeline Replacing Delivery Canal

The initial capital investment associated with the 'Multi-Size Pipeline' capital renovation is $3,748,425 in 2002 nominal dollars (**Table 6**). Combining that cost with the changes in O&M expenditures over the 50-year planning horizon and calculating the net present value (NPV) of that flow of funds contributes to the $1,790,127 value noted at the top of the 'Multi-Size Pipeline' column in **Table 30.** This value is again higher than the corresponding $1,232,675 value in **Table 29** because of the ignoring of energy savings when calculating the 'Cost of Energy Saved.' The nominal energy savings anticipated during the 50-year planning period total 121,101,520,577 BTU (35,492,825 kwh) (**Table 19**). Discounted into a real 2002 value, those savings are estimated to be 50,715,948,012 BTU (14,863,994 kwh) (**Table 19**). Converting both of the real 2002 values into annuity equivalents per the methodology presented in Rister et al. 2002 results in an annual cost estimate of $115,560 to achieve 2,360,837,546 BTU (691,922 kwh) of energy savings per year (**Table 30**). Dividing the first annuity estimate by the second annuity estimate results in the annuity cost estimate of $0.0000490 per BTU ($0.167 per kwh) of energy savings for the multi-size pipeline replacing delivery canal capital renovation (**Table 30**).

Aggregate Measure of Cost of Energy Savings

Combining the costs of the two components (i.e., 72" pipeline and multi-size pipeline replacing delivery canals) of the District's proposed project results in a total NPV net cost (i.e., both initial investments and changes in O&M expenditures) estimate of $2,787,293 which translates into an annuity cost equivalent of $179,931 per year (**Table 30**). The total NPV of energy savings is 64,917,483,882 BTU, representing an annuity equivalent of **3,021,921,887 BTU (885,675 kwh)**of energy savings. Performing the same math as used in calculating the costs of energy savings for the individual components (i.e., dividing the annuity of the net cost stream by the annuity amount of energy savings) produces the **$0.0000595 per BTU ($0.203 per kwh)** of energy savings aggregate cost measure (**Table 30**).

Limitations

The protocol and implementation of the analyses reported in this report are robust, providing insightful information regarding the potential performance of the project proposed by the District. There are limitations, however, to what the results are and are not and how they should and should not be used. The discussion below addresses such issues.

- The analyses are conducted from a District perspective, ignoring income and expense impacts on both water users (i.e., farmers and M&I consumers) and third-party beneficiaries (i.e., the indirect economic impact effects). The spatial component and associated efficiency issues of 28 independent Districts supplying water to an array of agricultural, municipal, and industrial users in a relatively concentrated area are cast aside.

- The analyses are *pro forma* budgeting in nature, based on forecasts of events and economic forces extending into the future several years. Obviously, there is imperfect information about such conditions, contributing to a degree of uncertainty as to the appropriate exact input values. Necessarily, such uncertainty contributes to some ambiguity surrounding the final result measures.

- Constrained financial resources, limited data availability, and a defined time horizon prohibit (a) extensive field experimentation to document all of the engineering- and water-related parameters; and (b) prolonged assimilation of economic costs and savings parameters. The immediate and readily-apparent status of needs for improvement across a wide array of potential projects and the political atmosphere characterizing the U.S.-Mexico water treaty situation discourage a slow, deliberate, elaborate, extensive evaluation process.

- Although the analyses' framework is deterministic, sensitivity analyses are included for several of the dominant parameters in recognition of the prior two limitations.

- Beyond the sensitivity analyses mentioned above, there is no accounting for risk in these analyses.

- The economic appraisal of the proposed project is objective and relatively simple in nature, providing straightforward estimates of the cost of water and energy saved. No benefit value of the water savings is conjectured to be forthcoming from the proposed project, i.e., a complete cost-benefit procedure is not applied. Consequently, the comprehensive issue of the net value of the proposed project is not addressed in this report.

- The project is evaluated as proposed, consisting in this case of multiple (i.e., two) components. While such components are assumed mutually independent in the analyses, their joint potential is the bottomline result presented in this report as opposed to them being identified as separate and distinct renovation alternatives. That is, per guidance from Bureau of Reclamation management (Shaddix), the project is appraised as proposed by the District, with the two components viewed as an 'all or none' opportunity.

- An individual project proposed by a District is evaluated in the positive, objective form noted earlier independent of other District's proposals. Should there be cause for comparison of potential performance across two or more proposed projects, such appraisals need to be conducted exogenous to this report. The results presented in the main body of this report could be useful for such prioritization processes, however, as discussed in Rister et al. (2002).

- No possible capital renovations to the District besides those contained in the designated proposal are evaluated in comparison to the components of this project proposal. That is, while there may be other more economical means of saving water and energy within the District, those methods are not evaluated here.

- The analyses of the proposed project are conditional on existing District, Rio Grande Valley, State, and Federal infrastructure, policies (e.g., Farm Bill, U.S.-Mexico Water Treaty, etc.), and other institutional parameters (e.g., Domestic, Municipal, and Industrial (DMI) reserve levels, water rights ownership and transfer policies, priority of M&I rights, etc.). The implicit assumption is that the 28 Irrigation Districts in the Rio Grande Valley will retain their autonomy, continuing to operate independently, with any future collaboration, merger, other form of reorganization, and/or change in institutional policies to have no measurable impacts on the performance of the proposed project.

- The projects analyzed in this and other forthcoming reports are limited to those authorized by the Congress as a result of processes initiated by individual Districts or as proposed for other funding should that occur. That is, no comprehensive *a priori* priority systematic plan has been developed whereby third-party entities identify and prioritize projects on a Valley-wide basis, thereby providing preliminary guidance on how best to allocate appropriated funding in the event such funds are limited through time.

While such caveats indicate real limitations, they should not be interpreted as negating of the results contained in this report. These results are bonafide and conducive for use in the appraisal of the proposed projects affiliated with Public Law 106-576 legislation as well as those projects being proposed to the BECC and NADBank. The above issues are worthy of consideration for future research and programs of work, but should not be misinterpreted and/or misapplied to the extent of halting efforts underway at this time.

Recommended Future Research

The analyses presented in this report are conditioned on the best information available, subject to the array of resource limitations and other problematic issues previously mentioned. Considering those circumstances, the results are highly useful for the Bureau of Reclamation's appraisal and prioritization of the several Rio Grande Basin projects already or potentially authorized by the Congress or submitted in a formal manner. Similarly, the results attend to the needs of BECC and NADBank in their review and certification of proposed projects. Nonetheless, there are opportunities for additional research and/or other programs of work that would provide valuable insight in a holistic manner of the greater issue of water resource management in the immediate Rio Grande Valley Basin area and beyond. These issues are related in large part to addressing the concerns noted in the "Limitations" section.

- A comprehensive economic impact study would provide an overall impact of the proposed renovations, thereby enhancing the economic strength of the analyses. Necessarily, it is suggested such an effort encompass a full cost-benefit assessment and potential alterations in cropping patterns, impacts of projected urban growth, distribution of water use across the Basin, etc. It is relevant to note that evaluation of Federal projects often employ a national perspective and consider such local impacts negligible. A more-localized perspective in the level of analyses results in greater benefits being estimated along with increased attention to the identity of 'winners' and 'losers' in the resulting adjustments that are anticipated. For example, while on a national perspective the issue of the 1.7 million ac-ft of water now owed to the U.S. may not be a high-priority issue, it certainly is viewed as a critical issue within the immediate Rio Grande Valley area.

- A continued, well-defined program akin to the Federal Rio Grande Basin Initiative would enhance information availability in regards to the engineering- and water-related parameters and related economic costs and savings parameters associated with capital renovations using existing and future technologies. It would be valuable to extend such efforts to District infrastructure and farm operations. A similar research agenda should be developed and implemented for the M&I sector of water users.

- Evaluating economies of size for optimal District operations, with intentions of recognizing opportunities for eliminating duplication of expensive capital items (e.g., pumping plants) and redundant O&M services would provide insight into potential for greater efficiency.

- Integration of risk would be useful in future analyses, including incorporation of stochastic elements for and correlation among the numerous parameters of consequence affecting the costs of water and energy measurements of interest. Such recognition of risk could extend beyond the immediate District factors to also allow for variance in the DMI reserve level policy under stochastic water availability scenarios and/or consideration of the effects of agricultural water rights being purchased by M&I users and converted, albeit at a less than 100% rate, from 'soft' to 'firm' rates.

- Attention is needed in identifying an explicit prioritization process for ranking projects competing for limited funds. Such a process could attend to distinguishing distinct components comprising a single project into separate projects and provide for consideration of other opportunities besides those proposed by an individual District whereby such latter projects are identified in the context of the total Rio Grande Basin as opposed to an individual District. Consideration of the development of an economic mixed-integer programming model (Agrawal and Heady) is suggested as a reasonable and useful complement to ongoing and future-anticipated engineering activities. Such an effort would provide a focal point for identifying and assimilating data necessary for both individual and comprehensive, Valley-wide assessments in a timely fashion.

- The issues of water rights ownership and transfer policies, priority of M&I rights, sources and costs of push water, etc. are admittedly contentious, but still should not be ignored as M&I demands accelerate and agricultural economic dynamics affect current and future returns to water used in such ventures.

- Development of a Valley- or Basin-wide based strategic capital investment plan is suggested, thereby providing preliminary guidance on how best to allocate appropriated funding; both agricultural and M&I use should be considered in such a plan.

- Detailed studies of Districts' water pricing (e.g., flat rates versus volumetric) policies, effects of water rights, conventions on sales and leasing of water rights, and various other issues relating to economic efficiency of water use could contribute insights on improved incentives for water conservation and capital improvement financing.

- Consideration of including M&I users as responsible parties for financing capital improvements is warranted.

Clearly, this is not a comprehensive list of possible activities germane to water issues in the Rio Grande Basin and/or the management of Irrigation Districts therein. The items noted could facilitate development, however, of proactive approaches to addressing current and emerging issues in the Rio Grande Basin area and beyond.

Summary and Conclusions

The District's project proposal consists of two components: 72" pipeline and multi-size pipeline replacing delivery canals. Their required respective capital investment costs are $1,264,299 and $3,748,425 (total of $5,012,724). A one-year installation period with an ensuing 49-year useful life (total of 50-year planning period) for each project component is expected. Net annual O&M expenditures are expected to increase with both components (**Table 6**).

Off- and *on-farm* water savings are predicted to be forthcoming from both components. Component #1's (72" pipeline) expected water savings over its 49-year useful life are 70,070 nominal ac-ft, which translate into a 2002 basis of 29,345 real ac-ft (**Table 9**). Component #2's (multi-size pipeline) expected water savings over its 49-year useful life are 167,181 nominal ac-ft, which translate into a 2002 basis of 70,013 real ac-ft (**Table 19**). Across the total project, nominal water savings are 237,251 ac-ft (**Tables 9** and **19**) and real 2002 savings are 99,358 ac-ft. On an average, annual, real basis, this totals **4,625 ac-ft** across both components (**Table 29)**.

Energy savings estimates associated with the 72" pipeline are 33,910,981,766 BTU (9,938,740 kwh) in nominal terms and 14,201,535,869 BTU (4,162,232 kwh) in real 2002 terms (**Table 9**). Similar estimates associated with the multi-size pipeline are 121,101,520,577 BTU (35,492,825 kwh) in nominal terms and 50,715,948,012 BTU (14,863,994 kwh) in real 2002 terms (**Table 19**). For the total project, nominal energy savings are 155,012,502,343 BTU (45,431,565 kwh) and real 2002 savings are 64,917,483,882 BTU (19,026,226 kwh) (**Table 9**, **19**, and **30**). On an average, annual, real basis, this totals **3,021,921,887 BTU (885,675 kwh)** across both components (**Table 30)**.

Economic and financial costs of *water* savings forthcoming from the 72" pipeline are estimated at $42.87 per ac-ft; while those for the multi-size pipeline are estimated at $24.42 (**Table 9**, **19**, and **29**). Sensitivity analyses indicate these estimates can be affected by variances in (a) the amount of reduction in Rio Grande River diversions resulting from the purchase, installation, and implementation of the pipeline; (b) the expected useful life of the pipeline; (c) the initial capital investment costs of the pipeline; and (d) the value of BTU savings (i.e., cost of energy).

Economic and financial costs of *energy* savings forthcoming from the 72" pipeline are estimated at $0.0000974 per BTU ($0.332 per kwh); while those for the multi-size pipeline are estimated at $0.0000490 per BTU ($0.167 per kwh) (**Table 9**, **19**, and **29**). Sensitivity analyses indicate factors of importance are (a) the amount of energy savings resulting from the purchase, installation, and implementation; (b) the expected useful life of the investment; (c) the initial capital investment costs; and (d) the amount of *off*- and *on-farm* water savings.

Aggregation of the economic and financial costs of water and energy savings for the individual project components into cost measures for the total project result in estimates of **$29.87 per ac-ft** cost of water savings (**Table 29**) and **$0.0000595 per BTU ($0.203 per kwh)** cost of energy savings (**Table 30**). These estimates, similar to the other economic and financial cost estimates identified here, are based on methods described in Rister et al. (2002).

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Glossary

Annuity equivalents: Expression of investment costs (from project components with differing life spans) in relation to water (or energy) savings expressed on an annualized basis into perpetuity. As used in this report/analyses, a form of a common denominator used to establish values for capital investments of unequal useful lives on a common basis so that comparisons across investment alternatives can be made, as well as combined into an aggregate measure when two or more components comprise a total proposed project.

BTU: British Thermal Unit, a standard measure of energy equal to 0.0002931 kilowatts; or, 3,412 BTU equals 1 kilowatt**.**

Canal lining: Concrete and/or a combination of concrete and synthetic plastic material placed in an earthen canal to prevent seepage, resulting in increase flow rates.

Capital budgeting analysis: Financial analysis method which discounts future cash flow streams into a consistent, present-day, real value, facilitating comparison of capital investment projects having different planning horizons (i.e., years) and/or involving uneven annual cost streams.

Charged system: Condition when canals are "full" and have enough water to facilitate the flow of water to a designated delivery point.

Component: One independent capital investment aspect of a District's total proposed capital renovation project.

Delivery system: The total of pumping stations, canals, etc. used to deliver water within an irrigation district.

Diversion points: Point along a canal where end users appropriate irrigation water, using either pumping or gravity flow through a permanent valve apparatus.

DMI Reserve: Domestic, municipal, and industrial surplus reserves held in the Falcon and Amistad reservoirs per Allocation and Distribution of Waters policy (Texas Natural Resource Conservation Commission).

Drip/Micro emitter systems: Irrigation systems used in horticultural systems which, relative to furrow irrigation, use smaller quantities of water at higher frequencies.

Flood irrigation: Common form of irrigation whereby fields are flooded through gravity flow.

Geographic Information System (GIS): Spatial information systems involving extensive, satellite-guided mapping associated with computer database overlays.

Head: Standard unit of measure of the flow rate of water; represents 3 cubic feet per second (Carpenter; Fipps 2001-2002).

Lateral: Smaller canal which branch off from main canals, and deliver water to end users.

Lock system: A system to lift water in a canal to higher elevations.

M&I: Municipal and industrial sources of water demand.

Mains: Large canals which deliver water from pumping stations to/across an irrigation district.

Nominal basis: Refers to non-inflation adjusted dollar values.

O&M: Operations and maintenance activities that represent variable costs.

Off-farm savings: Conserved units of water or energy that otherwise would have been expended in the irrigation district, i.e., during pumping or conveyance through canals.

On-farm savings: Conserved units of water or energy realized at the farm level.

Percolation losses: Losses of water in a crop field during irrigation due to seepage into the ground, below the root zone.

Polypipe: A flexible, hose-like plastic tubing used to convey water from field diversion points directly to the field.

Pro forma: Refers to projected financial statements or other performance measures.

Proration: Allocation procedure in which a quantity of water that is smaller than that authorized by collective water rights is distributed proportionally among water rights holders.

Push water: Water filling a District's delivery system used to propel (or transport) "other water" from the river-side diversion point to municipalities.

Real values: Numbers which are expressed in time- and sometimes inflation-adjusted terms.

Relift pumping: Secondary pumping of water to enable continued gravity flow through a canal.

Sensitivity analyses: Analysis to examine outcomes over a range of values for a given parameter.

Telemetry: Involving a wireless means of data transfer.

Turnout: Refers to the yield of water received by the end user at the diversion point.

Volumetric pricing: Method of pricing irrigations based on the precise quantity of water used, as opposed to pricing on a per-acre or per-irrigation basis.

Exhibits

Figure 1.

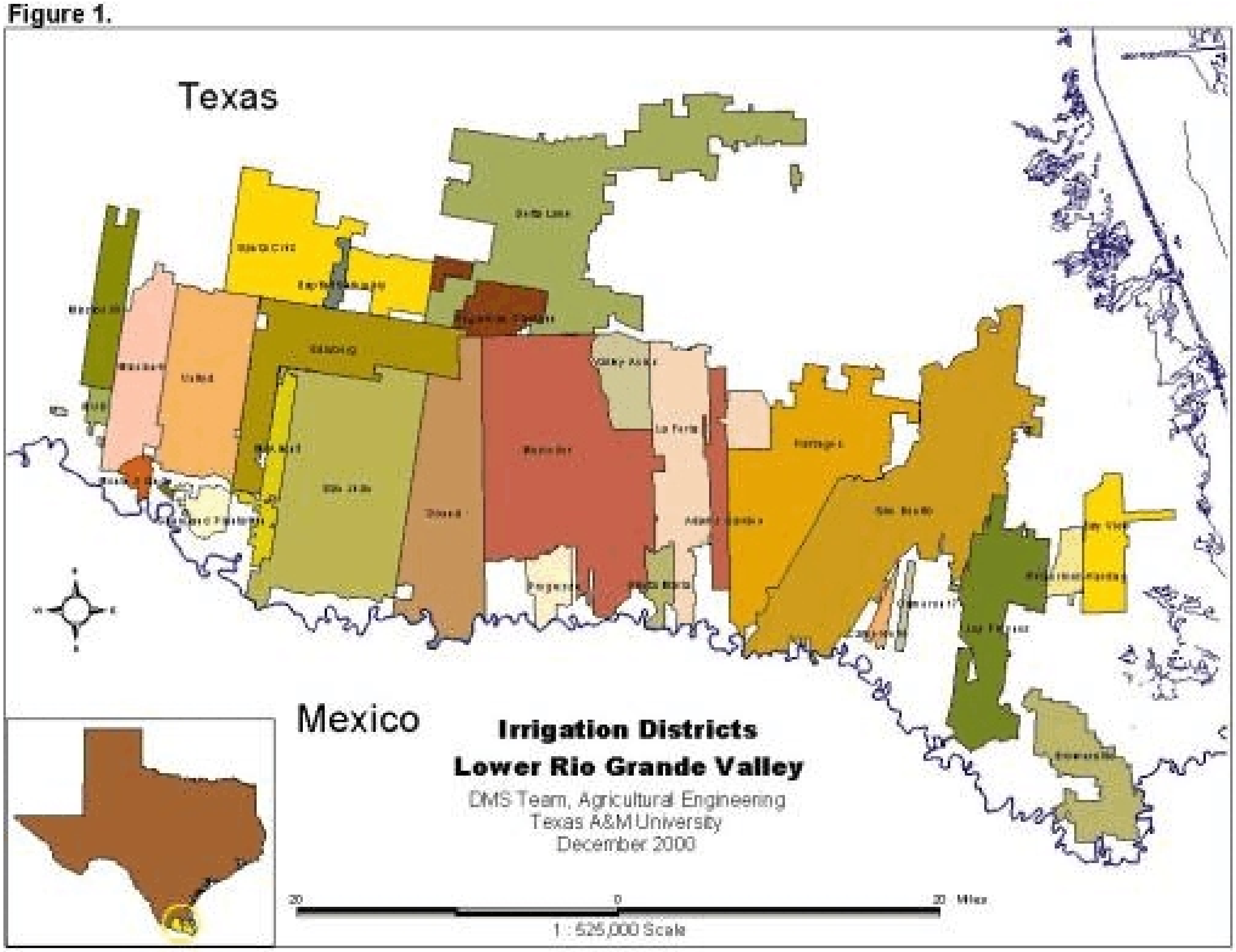

Exhibit 1. Illustration of Twenty-Eight Irrigation Districts in the Texas Lower Rio Grande Valley (Fipps et al.).

Exhibit 2. Edinburg, TX – Location of Edinburg Irrigation District Hidalgo County No. 1 Office (MapQuest).

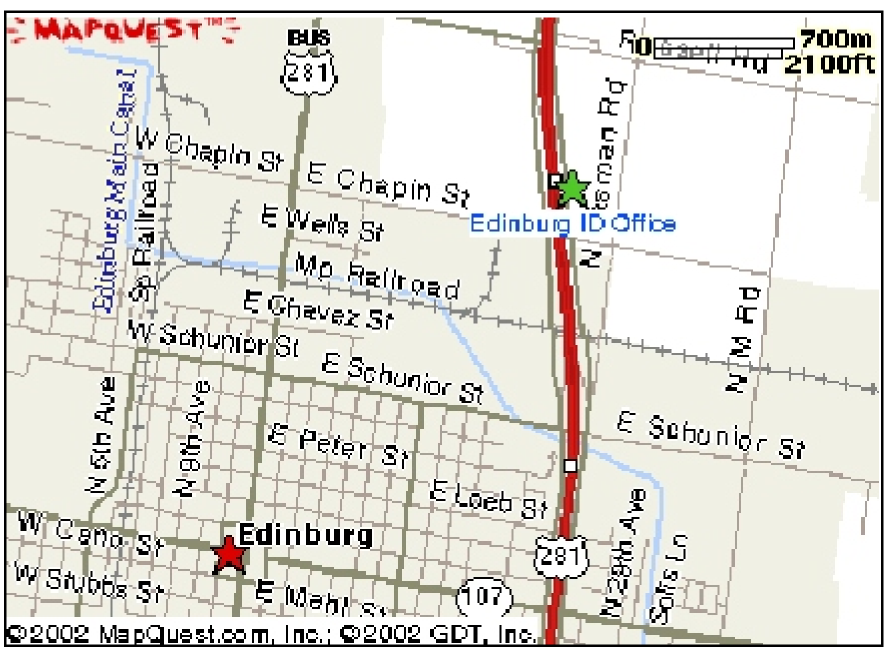

Exhibit 3. Detailed Location of Edinburg Irrigation District Hidalgo County No. 1 Office in Edinburg, TX (MapQuest).

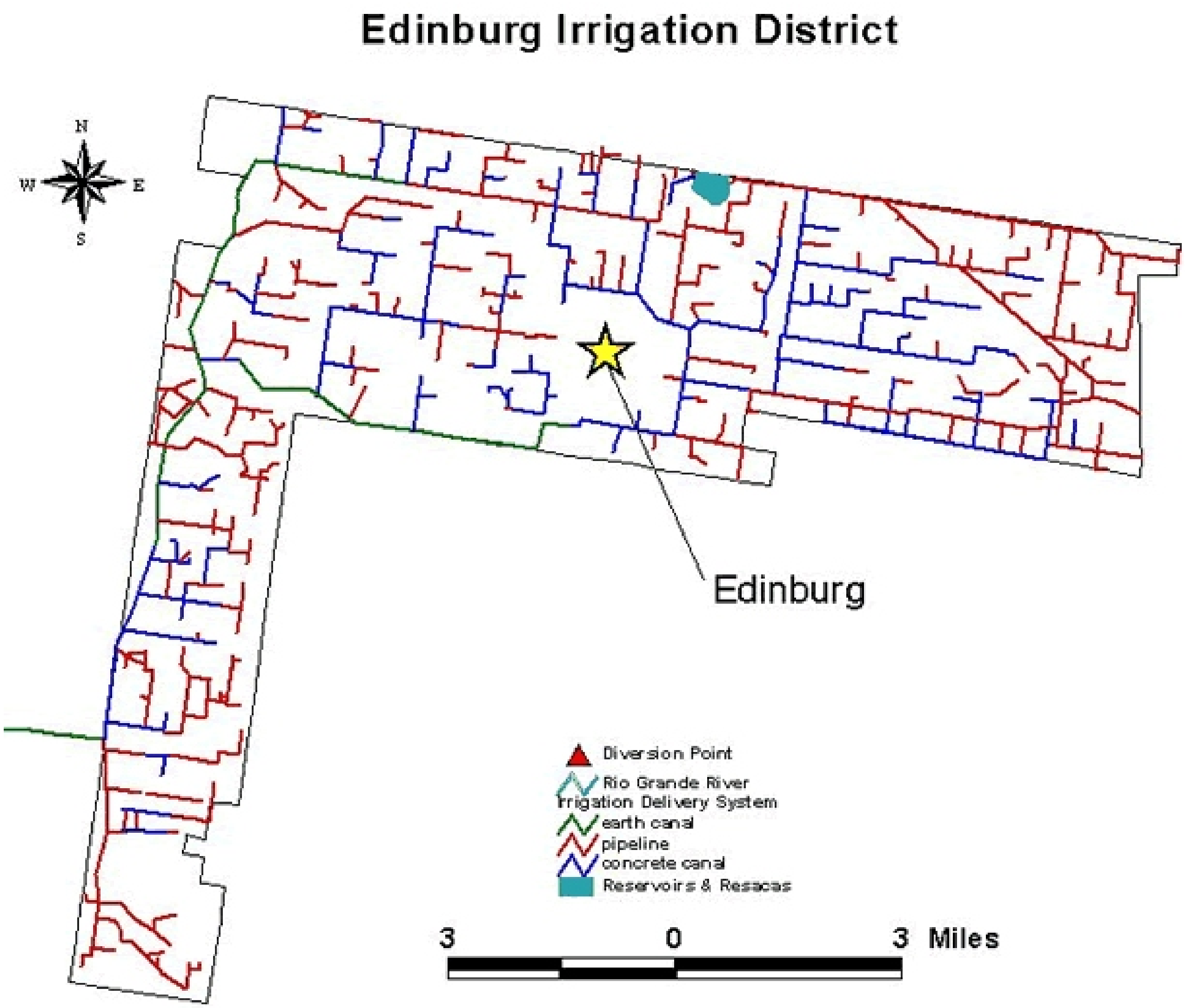

Exhibit 4. Illustrated Layout of Edinburg Irrigation District Hidalgo County No. 1 (Fipps et al.).

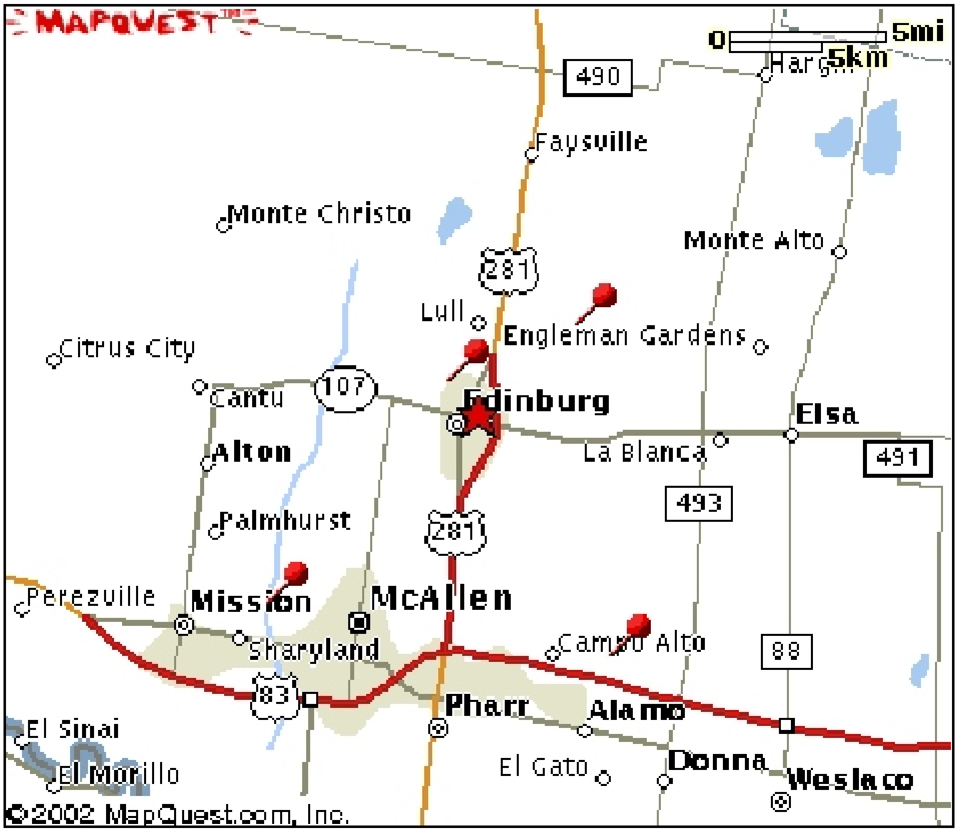

Exhibit 5. Location of Municipalities, Water Supply Corporations, and Irrigation Districts Served by Edinburg Irrigation District Hidalgo County No. 1 (MapQuest).

Tables

Table 1. Average Acreage Irrigated by Edinburg Irrigation District Hidalgo County No. 1 as per District Records for Calendar Years 1999-2001 (Carpenter).

Crop	**Acres**	**%**
Vegetables	10,260	35.5
Other[a]	7,359	25.5
Citrus	6,439	22.3
Corn	2,383	8.2
Sugarcane	893	3.1
Cotton	905	3.1
Grain sorghum	661	2.3
Total	28,899	100.0

[a] 'Other' includes golf courses, ponds, yards, etc.

Table 2. Historic Water Use Levels (acre-feet), Edinburg Irrigation District Hidalgo County No. 1, 1998-2001 (Carpenter).

Use	**1998**	**1999**	**2000**	**2001**	**4 year (1998-2001) average**
Ag	60,828	53,792	64,933	67,661	61,804
M&I	10,038	8,814	8,741	10,466	9,515
Total	70,866	62,606	73,674	78,127	71,318

Table 3. Summary of Diversion and Delivery Factors, Acres Served by Component, and Acreage Suited to Drip/Micro-Jet Water Delivery, Edinburg Irrigation District Hidalgo County No. 1, by Component, 2002 (Carpenter).

Item	Component #1 "Curry"	Component #2 "North Branch / East Main"
Average Ac-ft of Irrigation Water Diverted (est.)	.80 ac-ft	.80 ac-ft
Average Ac-ft of Irrigation Water Delivered (est.)	.61 ac-ft	.61 ac-ft
Total Irrigatable Acres Serviced	7,500 acres	3,783 acres
Gross Acreage Suitable for Drip/Micro-Jet Adoption	750 acres	1,200 acres
Net Acreage Estimated to Adopt Drip/Micro-Jet (50%)	375 acres	600 acres

Table 4. Calculations Documenting Energy Use and Expenses for Edinburg Irrigation District Hidalgo County No. 1, Per District Records (Carpenter).

	Fiscal Year		
Item	2000	2001	Average
Annual Cost - Electricity	$21,969	$97,894	
Annual Cost - Natural Gas	$171,389	$178,894	
Annual Cost - Total	$193,358	$276,788	$235,073
Water Diverted (ac-ft)	73,674	78,127	75,900
BTU used - Electricity	1,082,674,737	4,824,405,331	
BTU used - Natural Gas	33,098,880,404	34,548,256,370	
BTU used - Total	34,181,555,142	39,372,661,702	36,777,108,422
BTU/ac-ft water diverted	463,960	503,957	483,959
Energy Cost ($/BTU)	$0.0000057	$0.0000070	$0.0000063
Energy Cost ($/kwh)	$0.0193	$0.0240	$0.0216
Energy Cost ($/ac-ft)	$2.63	$3.54	$3.08

Table 5. Current Concrete-Lined Delivery Canals Proposed for Conversion to Pipelines, Edinburg Irrigation District Hidalgo County No. 1, 2002 (Carpenter).

Current Concrete-lined Delivery Canal Segments	**pipe diameter (inches)**	**length (feet)**	**length (miles)**
Curry	72	5,300	
Curry	24	200	
Curry	15	400	
sub-total		5,900	1.12
N. Branch / E. Main	60	10,900	
N. Branch / E. Main	54	5,300	
N. Branch / E. Main	48	10,400	
N. Branch / E. Main	24	1,000	
N. Branch / E. Main	15	1,000	
sub-total		28,600	5.42
total		34,500	6.54

Table 6. Summary of Project Cost Data (basis 2002), Edinburg Irrigation District Hidalgo County No. 1, Components 1 and 2, and Aggregate, 2002 (Carpenter).

Item	Component #1 (72" Pipeline) [a]			Component #2 (Multi-Size Pipeline) [b]			Aggregate [c]
	Years	Expenses / Revenues (total $'s)	Expenses / Revenues ($/mile)	Years	Expenses / Revenues (total $'s)	Expenses / Revenues ($/mile)	Expenses / Revenues (total $'s)
Installation Period	1			1			
Productive Period	49			49			
Planning Period	50			50			
Initial Capital Investment Costs		$1,264,299	$1,131,440		$3,748,425	$692,017	$5,012,724
Annual Increases in O&M Expenses		$827[d]	$827[d]		$4,482	$827	$5,309
Annual Decreases in O&M Expenses		$13,830[d]	$13,830[d]		$74,913	$13,830	$88,743
Net Changes in Annual O&M Expenses		$13,003[d]	$13,003[d]		$70,431	$13,003	$83,434
Value of Reclaimed Property (revenue) [e]		$0.00			$511,364		$511,364

[a] Component #1 is 5,900 feet (1.12 miles) of mostly 72" pipeline replacing concrete-lined canal in a segment of the Curry Main canal.

[b] Component #2 is 28,600 feet (5.42 miles) of multi-size pipeline (mostly 60", 54", and 48") replacing concrete-lined canal in a segment of the North Branch / East Main.

[c] The installation, productive, and planning periods (in years) are not additive and are not presented in the Aggregate of components 1 and 2.

[d] Although the project length (5,900') exceeds one mile, the additional footage of 24" and 15" pipe is not expected to provide changes in O&M expenses or water savings. Thus, the component's calculations are based as if the total component length is one mile.

[e] Funds received for reclaimed property (i.e., sold) are assumed received by the District in a lump-sum value at the project's initiation. This is based on 75% marketability of affected land, resulting in 34.09 acres at $15,000 per acre (Carpenter). Although the actual sales may occur several future years, the value of savings used in the analyses are expressed in present value 2002 dollars.

Table 7. Summary of Water Savings Data (basis 2002) for Project Component #1, 72" Pipeline Replacing Delivery Canal, Edinburg Irrigation District Hidalgo County No. 1, 2002 (Carpenter).

	Data and Amount of Savings by Area			Combined Water Savings	Annual Energy Savings		
	Reduced Seepage	Reduced Percolation & Drip/Micro-Jet Adoption					
Item/Savings	ac-ft per mile	% Ag or Total	Net Affected Acres	Total ac-ft	BTU	kwh's	$'s
Annual Energy & Water Savings							
Agricultural Irrigation Use:							
Off-farm (eliminated seepage)	500			500.0	241,979,319	70,920	$1,535
Off-farm (reduced relift)			n/a	n/a			
On-farm (reduced percolation loss)		15% of Ag water	7,125	855.0	413,784,636	121,273	$2,625
On-farm (drip/micro-jet adoption)		25% of Ag water	375	75.0	36,296,898	10,638	$230
Sub-total			7,500	1,430.0	692,060,853	202,831	$4,390
Municipal and Industrial Use:							
Off-farm							
On-farm							
On-farm (reduced relift)			n/a	n/a	n/a	n/a	n/a
Sub-total			0	0	0	0	0
Total			7,500	1,430.0	692,060,853	202,831	$4,390

Table 8. Summary of Water Savings Data (basis 2002) for Project Component #2, Multi-Size Pipeline Replacing Delivery Canal, Edinburg Irrigation District Hidalgo County No. 1, 2002.

Item/Savings	Data and Amount of Savings by Area: Reduced Seepage	Data and Amount of Savings by Area: Reduced Percolation & Drip/Micro-Jet Adoption		Combined Water Savings	Annual Energy Savings		
	ac-ft per mile	% Ag or Total	Net Affected Acres	Total ac-ft	BTU	kwh's	$'s
Annual Energy & Water Savings							
Agricultural Irrigation Use:							
Off-farm (eliminated seepage)	489.9[a]			2,655.3	1,285,031,174	376,621	$8,151
Off-farm (reduced relift)		15% of all water			820,265,324	240,406	$16,691
On-farm (reduced percolation loss)		25% of Ag water	3,183	636.6	308,088,069	90,295	$1,954
On-farm (drip/micro-jet adoption)		25% of Ag water	600	120.0	58,075,037	17,021	$368
Sub-total			3,783	3,411.9	2,471,459,604	724,343	$27,165
Municipal and Industrial Use:							
Off-farm							
On-farm							
On-farm (reduced relift)			n/a	n/a	n/a	n/a	n/a
Sub-total			0	0	0	0	0
Total			3,783	3,411.9	2,471,459,604	724,343	$27,165

[a] Weighted-average estimate, assuming 325 ac-ft per mile for 3.7 miles, 500 ac-ft per mile for 1.25 miles, and 1,000 ac-ft per mile for 1.0 mile.

Table 9. Economic and Financial Evaluation Results, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Results	Nominal	Real
Water Savings (ac-ft)		
Agriculture Irrigation	70,070	29,345
M&I	0	0
Total ac-ft	70,070	29,345
Energy Savings (BTU)		
Agriculture Irrigation	33,910,981,766	14,201,535,869
M&I	0	0
Total BTU	33,910,981,766	14,201,535,869
Energy Savings (kwh)		
Agriculture Irrigation	9,938,740	4,162,232
M&I	0	0
Total kwh's	9,938,740	4,162,232
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	$(237,761)	$907,081
Cost of Water Savings ($/ac-ft)		$42.87
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and	$141,274	$997,166
Cost of Energy Savings ($/BTU)		$0.0000974
Cost of Energy Savings ($/kwh)		$0.332

Table 10. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

	ac-ft of water leaks per linear mile of existing concrete-lined canal										
		125	200	300	400	450	**500**	550	600	650	750
Expected Useful life of Investment (years)	10	$390.78	$240.85	$157.56	$115.91	$102.03	$90.92	$81.84	$74.26	$67.86	$57.60
	20	$251.42	$154.96	$101.37	$74.57	$65.64	$58.50	$52.65	$47.78	$43.66	$37.06
	25	$225.81	$139.18	$91.04	$66.98	$58.96	$52.54	$47.29	$42.91	$39.21	$33.29
	30	$209.88	$129.36	$84.62	$62.25	$54.80	$48.83	$43.95	$39.89	$36.44	$30.94
	40	$192.22	$118.47	$77.50	$57.02	$50.19	$44.72	$40.25	$36.53	$33.38	$28.34
	49	$184.24	$113.55	$74.28	$54.65	$48.10	**$42.87**	$38.58	$35.01	$31.99	$27.16

Table 11. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

	ac-ft of water leaks per linear mile of existing concrete-lined canal										
		125	200	300	400	450	**500**	550	600	650	750
Initial Capital Investment Cost ($)	$(500,000)	$89.72	$54.48	$34.90	$25.11	$21.85	$19.24	$17.10	$15.32	$13.82	$11.41
	$(250,000)	$136.98	$84.02	$54.59	$39.88	$34.98	$31.05	$27.84	$25.17	$22.90	$19.28
	$(100,000)	$165.34	$101.74	$66.41	$48.74	$42.85	$38.14	$34.29	$31.07	$28.36	$24.01
	$ -	$184.24	$113.55	$74.28	$54.65	$48.10	**$42.87**	$38.58	$35.01	$31.99	$27.16
	$100,00	$203.14	$125.37	$82.16	$60.55	$53.35	$47.59	$42.88	$38.95	$35.63	$30.31
	$250,000	$231.50	$143.09	$93.97	$69.42	$61.23	$54.68	$49.32	$44.86	$41.08	$35.04
	$500,000	$278.75	$172.63	$113.66	$84.18	$74.36	$66.50	$60.06	$54.70	$50.17	$42.91

Table 12. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Value of Energy Savings, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		ac-ft of water leaks per linear mile of existing concrete-lined canal									
		125	200	300	400	450	**500**	550	600	650	750
Value of Energy Savings ($/kwh)	$0.0150	$185.55	$114.86	$75.59	$55.95	$49.41	$44.17	$39.89	$36.32	$33.30	$28.47
	$0.0175	$185.05	$114.37	$75.10	$55.46	$48.92	$43.68	$39.40	$35.83	$32.81	$27.97
	$0.0200	$184.56	$113.88	$74.61	$54.97	$48.43	$43.19	$38.91	$35.34	$32.32	$27.48
	$0.0216	$184.24	$113.55	$74.28	$54.65	$48.10	**$42.87**	$38.58	$35.01	$31.99	$27.16
	$0.0300	$182.59	$111.91	$72.64	$53.00	$46.46	$41.22	$36.94	$33.37	$30.35	$25.52
	$0.0350	$181.61	$110.93	$71.66	$52.02	$45.48	$40.24	$35.96	$32.39	$29.36	$24.53
	$0.0400	$180.63	$109.94	$70.67	$51.04	$44.49	$39.26	$34.97	$31.40	$28.38	$23.55

Table 13. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.00025816	$0.00022948	$0.00021740	$0.00021183	$0.00020653	$0.00020149	$0.00019669	$0.00018775	$0.00016522	$0.00013769
	20	$0.00016610	$0.00014764	$0.00013987	$0.00013629	$0.00013288	$0.00012964	$0.00012655	$0.00012080	$0.00010630	$0.00008859
	25	$0.00014918	$0.00013260	$0.00012562	$0.00012240	$0.00011934	$0.00011643	$0.00011366	$0.00010849	$0.00009547	$0.00007956
	30	$0.00013865	$0.00012325	$0.00011676	$0.00011377	$0.00011092	$0.00010822	$0.00010564	$0.00010084	$0.00008874	$0.00007395
	40	$0.00012699	$0.00011288	$0.00010694	$0.00010419	$0.00010159	$0.00009911	$0.00009675	$0.00009235	$0.00008127	$0.00006773
	49	$0.00012171	$0.00010819	$0.00010250	$0.00009987	**$0.00009737**	$0.00009500	$0.00009274	$0.00008852	$0.00007790	$0.00006491

Table 14. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.880	$0.783	$0.741	$0.722	$0.704	$0.687	$0.671	$0.640	$0.563	$0.470
	20	$0.566	$0.503	$0.477	$0.465	$0.453	$0.442	$0.432	$0.412	$0.362	$0.302
	25	$0.509	$0.452	$0.428	$0.417	$0.407	$0.397	$0.388	$0.370	$0.326	$0.271
	30	$0.473	$0.420	$0.398	$0.388	$0.378	$0.369	$0.360	$0.344	$0.303	$0.252
	40	$0.433	$0.385	$0.365	$0.355	$0.346	$0.338	$0.330	$0.315	$0.277	$0.231
	49	$0.415	$0.369	$0.350	$0.341	**$0.332**	$0.324	$0.316	$0.302	$0.266	$0.221

Table 15. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.00006068	$0.00005394	$0.00005110	$0.00004979	$0.00004855	$0.00004736	$0.00004624	$0.00004413	$0.00003884	$0.00003237
	$(250,000)	$0.00009120	$0.00008107	$0.00007680	$0.00007483	$0.00007296	$0.00007118	$0.00006949	$0.00006633	$0.00005837	$0.00004864
	$(100,000)	$0.00010951	$0.00009734	$0.00009222	$0.00008985	$0.00008761	$0.00008547	$0.00008344	$0.00007964	$0.00007009	$0.00005840
	$ -	$0.00012171	$0.00010819	$0.00010250	$0.00009987	**$0.00009737**	$0.00009500	$0.00009274	$0.00008852	$0.00007790	$0.00006491
	$100,000	$0.00013392	$0.00011904	$0.00011278	$0.00010988	$0.00010714	$0.00010452	$0.00010204	$0.00009740	$0.00008571	$0.00007142
	$250,000	$0.00015223	$0.00013532	$0.00012819	$0.00012491	$0.00012178	$0.00011881	$0.00011598	$0.00011071	$0.00009743	$0.00008119
	$500,000	$0.00018275	$0.00016244	$0.00015389	$0.00014994	$0.00014620	$0.00014263	$0.00013923	$0.00013291	$0.00011696	$0.00009746

Table 16. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.207	$0.184	$0.174	$0.170	$0.166	$0.162	$0.158	$0.150	$0.132	$0.110
	$(250,000)	$0.311	$0.276	$0.262	$0.255	$0.249	$0.243	$0.237	$0.226	$0.199	$0.166
	$(100,000)	$0.373	$0.332	$0.314	$0.306	$0.299	$0.291	$0.285	$0.272	$0.239	$0.199
	$ -	$0.415	$0.369	$0.350	$0.341	**$0.332**	$0.324	$0.316	$0.302	$0.266	$0.221
	$100,000	$0.457	$0.406	$0.385	$0.375	$0.365	$0.356	$0.348	$0.332	$0.292	$0.244
	$250,000	$0.519	$0.461	$0.437	$0.426	$0.415	$0.405	$0.396	$0.378	$0.332	$0.277
	$500,000	$0.623	$0.554	$0.525	$0.511	$0.499	$0.486	$0.475	$0.453	$0.399	$0.332

Table 17. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduction in Rio Grande River Diversions Due to Off- and On-Farm Savings, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Off-Farm Ac-Ft of Water Savings per Mile of Pipeline	125	$0.00048686	$0.00043276	$0.00040999	$0.00039947	$0.00038949	$0.00037999	$0.00037094	$0.00035408	$0.00031159	$0.00025966
	200	$0.00030429	$0.00027048	$0.00025624	$0.00024967	$0.00024343	$0.00023749	$0.00023184	$0.00022130	$0.00019474	$0.00016229
	300	$0.00020286	$0.00018032	$0.00017083	$0.00016645	$0.00016229	$0.00015833	$0.00015456	$0.00014753	$0.00012983	$0.00010819
	400	$0.00015214	$0.00013524	$0.00012812	$0.00012484	$0.00012171	$0.00011875	$0.00011592	$0.00011065	$0.00009737	$0.00008114
	450	$0.00013524	$0.00012021	$0.00011389	$0.00011097	$0.00010819	$0.00010555	$0.00010304	$0.00009836	$0.00008655	$0.00007213
	500	$0.00012171	$0.00010819	$0.00010250	$0.00009987	**$0.00009737**	$0.00009500	$0.00009274	$0.00008852	$0.00007790	$0.00006491
	550	$0.00011065	$0.00009836	$0.00009318	$0.00009079	$0.00008852	$0.00008636	$0.00008430	$0.00008047	$0.00007082	$0.00005901
	600	$0.00010143	$0.00009016	$0.00008541	$0.00008322	$0.00008114	$0.00007916	$0.00007728	$0.00007377	$0.00006491	$0.00005410
	650	$0.00009363	$0.00008322	$0.00007884	$0.00007682	$0.00007490	$0.00007307	$0.00007133	$0.00006809	$0.00005992	$0.00004993
	750	$0.00008114	$0.00007213	$0.00006833	$0.00006658	$0.00006491	$0.00006333	$0.00006182	$0.00005901	$0.00005193	$0.00004328

Table 18. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduction in Rio Grande River Diversions Due to Off- and On-Farm Savings, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Off-Farm Ac-Ft of Water Savings per Mile of Pipeline	125	$1.660	$1.476	$1.398	$1.362	$1.328	$1.296	$1.265	$1.207	$1.063	$0.885
	200	$1.038	$0.922	$0.874	$0.851	$0.830	$0.810	$0.791	$0.755	$0.664	$0.553
	300	$0.692	$0.615	$0.583	$0.568	$0.553	$0.540	$0.527	$0.503	$0.443	$0.369
	400	$0.519	$0.461	$0.437	$0.426	$0.415	$0.405	$0.395	$0.377	$0.332	$0.277
	450	$0.461	$0.410	$0.388	$0.378	$0.369	$0.360	$0.351	$0.335	$0.295	$0.246
	500	$0.415	$0.369	$0.350	$0.341	**$0.332**	$0.324	$0.316	$0.302	$0.266	$0.221
	550	$0.377	$0.335	$0.318	$0.310	$0.302	$0.294	$0.287	$0.274	$0.241	$0.201
	600	$0.346	$0.307	$0.291	$0.284	$0.277	$0.270	$0.264	$0.252	$0.221	$0.184
	650	$0.319	$0.284	$0.269	$0.262	$0.255	$0.249	$0.243	$0.232	$0.204	$0.170
	750	$0.277	$0.246	$0.233	$0.227	$0.221	$0.216	$0.211	$0.201	$0.177	$0.148

Table 19. Economic and Financial Evaluation Results, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Results	Nominal	Real
Water Savings (ac-ft)		
Agriculture Irrigation	167,181	70,013
M&I	0	0
Total ac-ft	167,181	70,013
Energy Savings (BTU)		
Agriculture Irrigation	121,101,520,577	50,715,948,012
M&I	0	0
Total BTU	121,101,520,577	50,715,948,012
Energy Savings (kwh)		
Agriculture Irrigation	35,492,825	14,863,994
M&I	0	0
Total kwh's	35,492,825	14,863,994
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Including Energy Cost Savings	$(5,191,323)	$1,232,675
Cost of Water Savings ($/ac-ft)		$24.42
NPV of Initial Capital Investment Costs and Changes in O&M Expenditures, Ignoring Both Energy Cost Savings and Value of Water	$(2,845,852)	$1,790,127
Cost of Energy Savings ($/BTU)		$0.0000490
Cost of Energy Savings ($/kwh)		$0.167

Table 20. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		total ac-ft of water leaks on 5.42 miles of existing concrete-lined canal									
		1,500	1,750	2,000	2,250	2,500	**2,655**	2,750	3,000	3,500	4,000
Expected Useful life of Investment (years)	10	$98.63	$83.25	$71.71	$62.74	$55.56	$51.79	$49.69	$44.80	$37.11	$31.34
	20	$63.45	$53.56	$46.14	$40.37	$35.75	$33.32	$31.97	$28.82	$23.87	$20.16
	25	$56.99	$48.10	$41.44	$36.25	$32.11	$29.93	$28.71	$25.89	$21.44	$18.11
	30	$52.97	$44.71	$38.51	$33.70	$29.84	$27.81	$26.69	$24.06	$19.93	$16.83
	40	$48.51	$40.95	$35.27	$30.86	$27.33	$25.47	$24.44	$22.04	$18.25	$15.42
	49	$46.50	$39.25	$33.81	$29.58	$26.20	**$24.42**	$23.43	$21.12	$17.50	$14.78

Table 21. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		total ac-ft of water leaks on 5.42 miles of existing concrete-lined canal									
		1,500	1,750	2,000	2,250	2,500	**2,655**	2,750	3,000	3,500	4,000
Initial Capital Investment Cost ($)	$(500,000)	$28.97	$24.22	$20.66	$17.89	$15.68	$14.51	$13.87	$12.36	$9.98	$8.20
	$(250,000)	$37.73	$31.73	$27.24	$23.74	$20.94	$19.46	$18.65	$16.74	$13.74	$11.49
	$(100,000)	$42.99	$36.24	$31.18	$27.24	$24.09	$22.43	$21.52	$19.37	$15.99	$13.46
	$ -	$46.50	$39.25	$33.81	$29.58	$26.20	**$24.42**	$23.43	$21.12	$17.50	$14.78
	$100,000	$50.00	$42.25	$36.44	$31.92	$28.30	$26.40	$25.34	$22.87	$19.00	$16.09
	$250,000	$55.26	$46.76	$40.38	$35.42	$31.46	$29.37	$28.21	$25.50	$21.25	$18.06
	$500,000	$64.03	$54.27	$46.96	$41.27	$36.71	$34.32	$32.99	$29.89	$25.01	$21.35

Table 22. Costs per Acre-Foot of Water-Saved Sensitivity Analyses – Water Savings per Mile of Pipeline and Value of Energy Savings, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

	total ac-ft of water leaks on 5.42 miles of existing concrete-lined canal										
		1,500	1,750	2,000	2,250	2,500	**2,655**	2,750	3,000	3,500	4,000
Value of Energy Savings ($/kwh)	$0.0150	$51.49	$43.71	$37.88	$33.34	$29.71	$27.80	$26.75	$24.27	$20.38	$17.47
	$0.0175	$49.61	$42.03	$36.35	$31.93	$28.39	$26.53	$25.50	$23.09	$19.30	$16.45
	$0.0200	$47.73	$40.35	$34.82	$30.51	$27.07	$25.25	$24.25	$21.90	$18.21	$15.44
	$0.0216	$46.50	$39.25	$33.81	$29.58	$26.20	**$24.42**	$23.43	$21.12	$17.50	$14.78
	$0.0300	$40.22	$33.63	$28.69	$24.85	$21.77	$20.15	$19.26	$17.16	$13.86	$11.39
	$0.0350	$36.46	$30.27	$25.62	$22.01	$19.12	$17.60	$16.76	$14.79	$11.69	$9.37
	$0.0400	$32.70	$26.91	$22.56	$19.18	$16.47	$15.05	$14.26	$12.42	$9.52	$7.35

Table 23. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.00012978	$0.00011536	$0.00010929	$0.00010648	$0.00010382	$0.00010129	$0.00009888	$0.00009438	$0.00008306	$0.00006921
	20	$0.00008350	$0.00007422	$0.00007031	$0.00006851	$0.00006680	$0.00006517	$0.00006362	$0.00006073	$0.00005344	$0.00004453
	25	$0.00007499	$0.00006666	$0.00006315	$0.00006153	$0.00005999	$0.00005853	$0.00005714	$0.00005454	$0.00004799	$0.00004000
	30	$0.00006970	$0.00006196	$0.00005870	$0.00005719	$0.00005576	$0.00005440	$0.00005311	$0.00005069	$0.00004461	$0.00003717
	40	$0.00006384	$0.00005674	$0.00005376	$0.00005238	$0.00005107	$0.00004982	$0.00004864	$0.00004643	$0.00004086	$0.00003405
	49	$0.00006119	$0.00005439	$0.00005152	$0.00005020	**$0.00004895**	$0.00004775	$0.00004662	$0.00004450	$0.00003916	$0.00003263

Table 24. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Expected Useful Life of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Expected Useful life of Investment (years)	10	$0.443	$0.393	$0.373	$0.363	$0.354	$0.345	$0.337	$0.322	$0.283	$0.236
	20	$0.285	$0.253	$0.240	$0.234	$0.228	$0.222	$0.217	$0.207	$0.182	$0.152
	25	$0.256	$0.227	$0.215	$0.210	$0.205	$0.200	$0.195	$0.186	$0.164	$0.136
	30	$0.238	$0.211	$0.200	$0.195	$0.190	$0.186	$0.181	$0.173	$0.152	$0.127
	40	$0.218	$0.193	$0.183	$0.179	$0.174	$0.170	$0.166	$0.158	$0.139	$0.116
	49	$0.209	$0.185	$0.176	$0.171	**$0.167**	$0.163	$0.159	$0.152	$0.134	$0.111

Table 25. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.00004410	$0.00003920	$0.00003713	$0.00003618	$0.00003528	$0.00003442	$0.00003360	$0.00003207	$0.00002822	$0.00002352
	$(250,000)	$0.00005264	$0.00004679	$0.00004433	$0.00004319	$0.00004211	$0.00004109	$0.00004011	$0.00003828	$0.00003369	$0.00002808
	$(100,000)	$0.00005777	$0.00005135	$0.00004865	$0.00004740	$0.00004621	$0.00004509	$0.00004401	$0.00004201	$0.00003697	$0.00003081
	$ -	$0.00006119	$0.00005439	$0.00005152	$0.00005020	**$0.00004895**	$0.00004775	$0.00004662	$0.00004450	$0.00003916	$0.00003263
	$100,000	$0.00006460	$0.00005743	$0.00005440	$0.00005301	$0.00005168	$0.00005042	$0.00004922	$0.00004698	$0.00004135	$0.00003446
	$250,000	$0.00006973	$0.00006198	$0.00005872	$0.00005721	$0.00005578	$0.00005442	$0.00005313	$0.00005071	$0.00004463	$0.00003719
	$500,000	$0.00007828	$0.00006958	$0.00006592	$0.00006423	$0.00006262	$0.00006109	$0.00005964	$0.00005693	$0.00005010	$0.00004175

Table 26. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Initial Cost of the Capital Investment, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
Initial Capital Investment Cost ($)	$(500,000)	$0.150	$0.134	$0.127	$0.123	$0.120	$0.117	$0.115	$0.109	$0.096	$0.080
	$(250,000)	$0.180	$0.160	$0.151	$0.147	$0.144	$0.140	$0.137	$0.131	$0.115	$0.096
	$(100,000)	$0.197	$0.175	$0.166	$0.162	$0.158	$0.154	$0.150	$0.143	$0.126	$0.105
	$ -	$0.209	$0.185	$0.176	$0.171	**$0.167**	$0.163	$0.159	$0.152	$0.134	$0.111
	$100,000	$0.220	$0.196	$0.186	$0.181	$0.176	$0.172	$0.168	$0.160	$0.141	$0.117
	$250,000	$0.238	$0.211	$0.200	$0.195	$0.190	$0.186	$0.181	$0.173	$0.152	$0.127
	$500,000	$0.267	$0.237	$0.225	$0.219	$0.214	$0.208	$0.203	$0.194	$0.171	$0.142

Table 27. Costs per BTU of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduction in Rio Grande River Diversions Due to Off- and On-Farm Savings, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
total ac-ft of water leaks on 5.42 miles of existing concrete-lined canal	1,500	$0.00008626	$0.00007668	$0.00007264	$0.00007078	$0.00006901	$0.00006732	$0.00006572	$0.00006273	$0.00005521	$0.00004601
	1,750	$0.00007923	$0.00007043	$0.00006672	$0.00006501	$0.00006339	$0.00006184	$0.00006037	$0.00005762	$0.00005071	$0.00004226
	2,000	$0.00007327	$0.00006512	$0.00006170	$0.00006012	$0.00005861	$0.00005718	$0.00005582	$0.00005328	$0.00004689	$0.00003907
	2,250	$0.00006813	$0.00006056	$0.00005738	$0.00005590	$0.00005451	$0.00005318	$0.00005191	$0.00004955	$0.00004361	$0.00003634
	2,500	$0.00006367	$0.00005660	$0.00005362	$0.00005224	$0.00005094	$0.00004970	$0.00004851	$0.00004631	$0.00004075	$0.00003396
	2,655	$0.00006119	$0.00005439	$0.00005152	$0.00005020	**$0.00004895**	$0.00004775	$0.00004662	$0.00004450	$0.00003916	$0.00003263
	2,750	$0.00005976	$0.00005312	$0.00005033	$0.00004903	$0.00004781	$0.00004664	$0.00004553	$0.00004346	$0.00003825	$0.00003187
	3,000	$0.00005630	$0.00005005	$0.00004741	$0.00004620	$0.00004504	$0.00004394	$0.00004290	$0.00004095	$0.00003603	$0.00003003
	3,500	$0.00005046	$0.00004485	$0.00004249	$0.00004140	$0.00004037	$0.00003938	$0.00003845	$0.00003670	$0.00003229	$0.00002691
	4,000	$0.00004572	$0.00004064	$0.00003850	$0.00003751	$0.00003657	$0.00003568	$0.00003483	$0.00003325	$0.00002926	$0.00002438

Table 28. Costs per kwh of Energy-Saved Sensitivity Analyses – BTU of Energy Saved per Acre-Foot of Water Savings and Reduction in Rio Grande River Diversions Due to Off- and On-Farm Savings, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

		variation in BTU of all energy saved per ac-ft of water saved									
		80.0%	90.0%	95.0%	97.5%	**100.0%**	102.5%	105.0%	110.0%	125.0%	150.0%
		BTU of energy saved per ac-ft of water savings									
		387,167	435,563	459,761	471,860	**483,959**	496,058	508,157	532,355	604,948	725,938
total ac-ft of water leaks on 5.42 miles of existing concrete-lined canal	1,500	$0.294	$0.261	$0.248	$0.241	$0.235	$0.230	$0.224	$0.214	$0.188	$0.157
	1,750	$0.270	$0.240	$0.228	$0.222	$0.216	$0.211	$0.206	$0.196	$0.173	$0.144
	2,000	$0.250	$0.222	$0.210	$0.205	$0.200	$0.195	$0.190	$0.182	$0.160	$0.133
	2,250	$0.232	$0.207	$0.196	$0.191	$0.186	$0.181	$0.177	$0.169	$0.149	$0.124
	2,500	$0.217	$0.193	$0.183	$0.178	$0.174	$0.169	$0.165	$0.158	$0.139	$0.116
	2,655	$0.209	$0.185	$0.176	$0.171	**$0.167**	$0.163	$0.159	$0.152	$0.134	$0.111
	2,750	$0.204	$0.181	$0.172	$0.167	$0.163	$0.159	$0.155	$0.148	$0.130	$0.109
	3,000	$0.192	$0.171	$0.162	$0.158	$0.154	$0.150	$0.146	$0.140	$0.123	$0.102
	3,500	$0.172	$0.153	$0.145	$0.141	$0.138	$0.134	$0.131	$0.125	$0.110	$0.092
	4,000	$0.156	$0.139	$0.131	$0.128	$0.125	$0.122	$0.119	$0.113	$0.100	$0.083

Table 29. Economic and Financial Evaluation Results for Cost of Water Saved, Aggregated Across 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal, Edinburg Irrigation District Hidalgo County No. 1, 2002.

	Project Component		
Economic / Conservation Measures	**72" Pipeline Replacing Delivery Canal (Curry)**	**Multi-Size Pipeline Replacing Delivery Canal (N. Branch / E. Main)**	**Aggregate**
NPV of Net Cost Stream, Including Both Initial Investment Cost and Changes in O&M Expenditures ($)	$907,081	$1,232,675	$2,139,756
Annuity Equivalent of Net Cost Stream for Calculation of Annuity Equivalents ($/yr)	$58,556	$79,574	$138,130
NPV of All Water Savings (ac-ft)	29,345	70,013	99,358
Annuity Equivalent of All Water Savings Stream for Weighting of Annuity Equivalents (ac-ft/yr)	1,366	3,259	4,625
Annuity Equivalent of Costs per ac-ft of Water Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($)	$42.867	$24.416	$29.865

Table 30. Economic and Financial Evaluation Results for Cost of Energy Saved, Edinburg Irrigation District Hidalgo County No. 1, Aggregated Across 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal for NADBank Project, 2002.

	Project Component		
Economic / Conservation Measures	**72" Pipeline Replacing Delivery Canal (Curry)**	**Multi-Size Pipeline Replacing Delivery Canal (N. Branch / E. Main)**	**Aggregate**
NPV of Net Cost Stream, Including Both Initial Investment Cost and Changes in O&M Expenditures ($)	$997,166	$1,790,127	$2,787,293
Annuity Equivalent of Net Cost Stream for Calculation of Annuity Equivalents ($/yr)	$64,371	$115,560	$179,931
NPV of All Energy Savings (BTU)	14,201,535,869	50,715,948,012	64,917,483,882
Annuity Equivalent of All Energy Savings Stream for Weighting of Annuity Equivalents (BTU/yr)	661,084,341	2,360,837,546	3,021,921,887
Annuity Equivalent of All Energy Savings Stream for Weighting of Annuity Equivalents (kwh/yr)	193,753	691,922	885,675
Annuity Equivalent of Costs per BTU of Energy Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($)	$0.0000974	$0.0000490	$0.0000595
Annuity Equivalent of Costs per kwh of Energy Savings, Assuming Perpetual Timeline and Replacement with Identical Technology ($)	$0.332	$0.167	$0.203

Appendices

Appendix A: Legislated Criteria Results – By Component

United States Public Law 106-576 legislation requires three economic measures be calculated and included as part of the information prepared for the Bureau of Reclamation's evaluation of the proposed projects (Bureau of Reclamation):

- Number of ac-ft of water saved per dollar of construction costs;
- Number of BTU of energy saved per dollar of construction costs; and
- Dollars of annual economic savings per dollar of initial construction costs.

Discussions with Bob Hamilton of the Denver Bureau of Reclamation office on April 9, 2002 indicated these measures are often stated in an inverse mode, i.e.,

- Dollars of construction cost per ac-ft of water saved;
- Dollars of construction cost per BTU (and kwh) of energy saved; and
- Dollars of construction cost per dollar of annual economic savings.

Hamilton's suggested convention is adopted and used in the RGIDECON© model section reporting the Public Law 106-576 legislation's required measures. It is on that basis that the legislated criteria results are presented in both Appendices A and B of this report. Appendix A is focused on results for the individual capital renovation components comprising the total proposed project. Aggregated results for the total project are presented in Appendix B.

The noted criteria involve a series of calculations similar to, but different than, those used in developing the cost measures cited in the main body of this report. Principal differences consist of the legislated criteria not requiring aggregation of the initial capital investment costs with the annual changes in O&M expenditures, but rather entailing separate sets of calculations for each type of costs relative to the anticipated water and energy savings. While the legislated criteria do not specify the need for discounting the nominal values into real terms, both nominal and real values are presented in Appendix A to account for the differences in length of planning periods across multiple components of a single project and across different projects. With regards to the annual economic savings referred to in the third criteria, these are summed into a single present value quantity inasmuch as the annual values may vary through the planning period. Only real results are presented in Appendix B since the aggregation of results requires combining of results for the different components, necessitating a common basis of evaluation. Readers are directed to Rister et al. (2002) for more information regarding the issues associated with comparing capital investments having differences in length of planning periods.

Component #1 - 72" Pipeline (i.e., Curry Main)

Component #1 of the District's NADBank project consists of installing 5,900 feet of mostly 72" pipeline to replace a segment of concrete-lined delivery canal. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 6** and **9**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

The principal evaluation criteria specified in the United States Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A2** (as determined by the calculated values reported in **Table A1**, which are derived in RGIDECON©, using the several input parameters described in the main body of this report).

Summary Calculated Values

The initial construction costs associated with the purchase and installation of component #1 amount to $1,264,299. It is assumed all costs occur on the first day of the planning period, thus, the nominal and real values are equal because there are no future costs to discount.

A total of 70,070 ac-ft of nominal *off-* and *on-farm* water savings are projected to occur during the productive life of the 72" pipeline, with associated energy savings of 33,910,981,766 BTU (9,938,740 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 29,345 ac-ft and 14,201,535,869 BTU (4,162,232 kwh) (**Table A1**).

The accrued annual net changes in O&M expenditures over the 72" pipeline's productive life are a total decrease of $1,502,059. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $357,218 (**Table A1**). As noted in the main body of the text, this anticipated net cost savings stems from energy savings and anticipated changes in O&M expenditures.

Criteria Stated in Legislated Guidelines

The estimated initial construction costs per ac-ft of water saved are $18.04 in a nominal sense and $43.08 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000373 ($0.127) in a nominal sense and $0.0000890 ($0.304) in real terms (**Table A2**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the pipeline renovation result in anticipated net decreases in annual costs (**Table A1**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -0.84 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are less than the expected nominal decreases in O&M costs during the planning period for the installed 72" pipeline segment. On a real basis, this ratio measure is -3.54 (**Table A2**), however, signifying construction costs are substantially higher than the expected real values of economic savings in O&M during the planning period.

Component #2 -Multi-Size Pipeline (i.e., N. Branch / E. Main)

Component #2 of the District's NADBank project consists of installing 28,600 feet of multi-size pipeline to replace a segment of concrete-lined delivery canal. Details on the cost estimates and related projections of associated water and energy savings are presented in the main body of this report (**Tables 6** and **19**). Below, a summary of the calculated values and results corresponding to the legislated criteria are presented, with nominal and their discounted (i.e., real) transformations presented.

The principal evaluation criteria specified in the Public Law 106-576 legislation, transformed according to Hamilton, are presented in **Table A4** (which are determined by the calculated values reported in **Table A3**, which are derived in RGIDECON©, using the several input parameters described in the main body of this report).

Summary Calculated Values

The initial construction costs associated with the purchase and installation of component #1 amount to $3,748,425. It is assumed all costs occur on the first day of the planning period, thus, the nominal and real values are equal because there are no future costs to discount.

A total of 167,181 ac-ft of nominal *off*- and *on-farm* water savings are projected to occur during the productive life of the multi-size pipeline, with associated energy savings of 121,101,520,577 BTU (35,492,825 kwh). Using the 4% discount rate, the present or real value of such anticipated savings become 70,013 ac-ft and 50,715,948,012 BTU (14,863,994 kwh) (**Table A3**).

The accrued annual net changes in O&M expenditures over the multi-size pipeline's productive life are a total decrease of $8,939,748. Using the 2002 Federal discount rate of 6.125%, this anticipated net decrease in expenditures represents a real cost reduction of $2,515,750 (**Table A3**). As noted in the main body of the text, this anticipated net cost savings stems from energy savings and anticipated changes in O&M expenditures.

Criteria Stated in Legislated Guidelines

The estimated initial construction costs per ac-ft of water saved are $22.42 in a nominal sense and $53.54 in real terms, while the initial construction costs per BTU (kwh) of energy saved are $0.0000310 ($0.106) in a nominal sense and $0.0000739 ($0.252) in real terms (**Table A4**). The estimated real values are higher (than the nominal values) because future water and energy savings are discounted and construction costs are not because they occur at the onset, i.e., with the real or present values, the discounting of the denominators (i.e., ac-ft of water; BTU (or kwh) of energy) increases the ratio of $/water saved and $/energy saved.

Changes in both energy savings and other O&M expenditures forthcoming from the pipeline renovation result in anticipated net decreases in annual costs (**Table A4**). Dividing the initial construction costs by the decreases in operating costs results in a ratio measure of -0.42 of construction costs per dollar reduction in nominal operating expenditures, suggesting construction costs are less than the expected nominal decreases in O&M costs during the planning period for the installed multi-size pipeline segment. On a real basis, this ratio measure is -1.49 (**Table A4**), however, signifying construction costs are substantially higher than the expected real values of economic savings in O&M during the planning period.

Summary of Legislated Criteria Results for the Individual Components

Notably, the legislated criteria results differ for the two components comprising the District's proposed NADBank project. The numbers are dissimilar to the results presented in the main body of this report due to the difference in mathematical approaches, i.e., construction costs and O&M expenditures are not comprehensively evaluated per ac-ft of water savings and per BTU (kwh) of energy savings here.

In the main body of this report, the comprehensive assessment indicates the multi-size pipeline segment is a more economical source of *water savings* than the 72" pipeline segment (**Table 29**). The comprehensive costs of *energy savings* yielded similar rankings (**Table 30**).

Here, in the legislated criteria results, the 72" pipeline is the most economical in terms of dollars of initial construction costs per ac-ft of *water savings*, with the multi-size pipeline ranked last (**Tables A2** and **A4**). With respect to cost of *energy savings*, the 72" pipeline is not the most economical, with the multi-size pipeline out-performing it in dollars of initial construction costs per BTU of energy saved (**Tables A2** and **A4**). Finally, for the construction costs per dollar of economic savings in annual O&M criterion. The occurrence of net savings in O&M, for both the 72" pipeline and the multi-size pipeline components, appears favorable for both investments (**Tables A2** and **A4**). Between the two components, however, the 72" pipeline is not the most economical as the multi-size pipeline requires less initial construction cost per dollar of economic O&M savings. It is difficult to determine the rank order of these two components since either a low construction cost requirement and/or a high increase in O&M expenditures result in a low ratio of the two designated calculated values. Similarly, a high construction cost requirement and/or a low increase in O&M expenditures result in a high ratio of the two designated calculated values. The resulting paradox is apparent.

Recall, however, that according to the legislated guidelines, a project proposed by a District is to be evaluated in its entirety, rather than on the merits of individual components. **Appendix B** contains a commentary addressing the likely aggregate performance of the total project proposed by the District, using the legislated criteria modified to account, somewhat but not completely, for the differences in useful lives of the respective project components.

Appendix B: Legislated Criteria Results Aggregated Across Components

As noted in Rister et al. (2002), aggregation of evaluation results for independent projects into an appraisal of one comprehensive project is not a common occurrence. Adaptations in analytical methods are necessary to account for the variations in useful lives of the individual components. The approach used in aggregating the legislated criteria results presented in **Appendix A** into one set of uniform measures utilizes the present value methods followed in the calculation of the economic and financial results reported in the main body of the text, but does not include the development of annuity equivalent measures. These compromises in approaches are intended to maintain the spirit of the legislated criteria's intentions. Here in Appendix B, only real, present value measures are presented and discussed, thereby designating all values in terms of 2002 equivalents. **Differences in useful lives across project components are not fully represented, however, in these calculated values.**

Table B1 contains the summary measures for the two respective individual components (i.e., 72" pipeline replacing delivery canal and multi-size pipeline replacing delivery canal) and also a summed aggregate value for each measure. The project as a whole requires an initial capital construction investment of $5,012,724. In total, 99,358 ac-ft of real water savings are estimated. Real energy savings are anticipated to be 64,917,483,882 BTU (19,026,226 kwh). The net change in real total annual O&M expenditures is a decrease of $2,872,967.

Derivation of the aggregate legislated-criteria measures for the project as a whole entails use of the Aggregate column values presented in **Table B1** and calculations similar to those used to arrive at the measures for the independent project components. The resulting aggregate initial construction costs per ac-ft of water savings measure is $50.90 per ac-ft of water savings (**Table B2**). Note that this amount is higher than the comprehensive economic and financial value of **$29.87 per ac-ft** identified in **Table 29** and discussed in the main body of this report. The difference in these values is attributable both to the incorporation of both initial capital costs and changes in operating expenses in the latter value and its treatment of the differences in the useful lives of the respective components of the proposed project.

The resulting aggregate initial construction costs per BTU (kwh) of energy savings measure is $0.0000777 per BTU ($0.265 per kwh) (**Table B2**). These cost estimates are higher than the **$0.0000595 per BTU ($0.203 per kwh)** comprehensive economic and financial cost estimates identified in **Table 30** for reasons similar to those noted above with respect to the estimates of costs of water savings.

The final aggregate legislated criterion of interest is the amount of initial construction costs per dollar of total annual economic savings. The estimate for this ratio measure is -2.01, indicating that (a) the net change in annual O&M expenditures is negative, i.e., a reduction in O&M expenditures is anticipated; and (b) $2.01 of initial construction costs are expended for each such dollar reduction in O&M expenditures, with the latter represented in total real dollars accrued across the two project components' respective planning periods.

Appendix Tables

Table A1. Summary of Calculated Values, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$1,264,299	$1,264,299
Ac-Ft of Water Saved	70,070	29,345
BTU of Energy Saved	33,910,981,766	14,201,535,869
kwh of Energy Saved	9,938,740	4,162,232
$ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	$(1,502,059)	$(357,218)

Table A2. Legislated Evaluation Criteria, Edinburg Irrigation District Hidalgo County No. 1, 72" Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Criteria	Nominal PV	Real NPV
Dollar of Initial Construction Costs per Ac-Ft of Water Saved	$18.04	$43.08
Dollar of Initial Construction Costs per BTU of Energy Saved	$0.0000373	$0.0000890
Dollar of Initial Construction Costs per kwh of Energy Saved	$0.127	$0.304
$ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	-0.84	-3.54

Table A3. Summary of Calculated Values, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Item	Nominal PV	Real NPV
Dollars of Initial Construction Costs	$3,748,425	$3,748,425
Ac-Ft of Water Saved	167,181	70,013
BTU of Energy Saved	121,101,520,577	50,715,948,012
kwh of Energy Saved	35,492,825	14,863,994
$ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	$(8,939,748)	$(2,515,750)

Table A4. Legislated Evaluation Criteria, Edinburg Irrigation District Hidalgo County No. 1, Multi-Size Pipeline Replacing Delivery Canal Component of NADBank Project, 2002.

Criteria	Nominal PV	Real NPV
Dollar of Construction Costs per Ac-Ft of Water Saved	$22.42	$53.54
Dollar of Construction Costs per BTU of Energy Saved	$0.0000310	$0.0000739
Dollar of Construction Costs per kwh of Energy Saved	$0.106	$0.252
$ of Initial Construction Costs per $ of Annual Economic Savings (costs are + values and benefits [i.e., savings] are -)	-0.42	-1.49

Table B1. Summary of Calculated Values, Edinburg Irrigation District Hidalgo County No. 1, Aggregated Across 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal, 2002.

Economic / Conservation Measures	Project Component		Aggregate
	72" Pipeline Replacing Delivery Canal (Curry)	Multi-Size Pipeline Replacing Delivery Canal (N. Branch / E. Main)	
Dollars of Initial Construction Costs ($)	$1,264,298	$3,748,425	$5,012,724
Ac-Ft of Water Saved (ac-ft)	29,345	70,013	99,358
BTU of Energy Saved (BTU)	14,201,535,869	50,715,948,012	64,917,483,882
kwh of Energy Saved (kwh)	4,162,232	14,863,994	19,026,226
$ of Annual Economic Savings (- represents net savings and + represents net added costs) ($)	$(357,218)	$(2,515,750)	$(2,872,967)

Table B2. Legislated Results Criteria, Real Values, Edinburg Irrigation District Hidalgo County No. 1, Aggregated Across 72" Pipeline Replacing Delivery Canal and Multi-Size Pipeline Replacing Delivery Canal, 2002.

	Project Component		
Economic Measures	**72" Pipeline Replacing Delivery Canal (Curry)**	**Multi-Size Pipeline Replacing Delivery Canal (N. Branch / E. Main)**	**Aggregate**
Dollar of Initial Construction Costs per Ac-Ft of Water Saved ($/ac-ft)	$43.08	$53.54	$50.902
Dollar of Initial Construction Costs per BTU of Energy Saved ($/BTU)	$0.0000890	$0.0000739	$0.0000777
Dollar of Initial Construction Costs per kwh of Energy Saved ($/kwh)	$0.304	$0.252	$0.265
Dollar of Initial Construction Costs per Dollar of Annual Economic Savings (- represents net savings and + represents net added costs) [a]	-3.54	-1.49	-2.01

[a] Negative values are indicative of expected net reductions in O&M expenditures during the planning horizon to current practices and capital installations.

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