# Arroyo Colorado Watershed
## Nonpoint Source Pollution Project

## Table of Contents



Final Report
February 1998

**TIAER**
**PR 98-02**

**Participating Agencies:**
Texas State Soil and Water Conservation Board
Southmost Soil and Water Conservation District
Texas Institute for Applied Environmental Research
Texas Agricultural Extension Service
Natural Resources Conservation Service

# ARROYO COLORADO WATERSHED NONPOINT SOURCE POLLUTION PROJECT FINAL REPORT

## TEXAS STATE SOIL AND WATER CONSERVATION BOARD

CONTRACT #994-592-713-4200000051
FY92 CWA SECTION 319(h)
**FEBRUARY 1998**

Final Report prepared by Nancy Easterling, TIAER
TAEX Report prepared by Guy Fipps
TIAER Report prepared by Joan Flowers, Nancy Easterling, and Larry Hauck

Texas Institute for Applied Environmental Research
Tarleton State University • Box T0410 •Tarleton Station • Stephenville • Texas • 76402
(254) 968-9567 • FAX (254) 968-9568

# ACKNOWLEDGMENTS

The Texas State Soil and Water Conservation Board (TSSWCB) is especially indebted to the two landowners that participated in this project, George Labar and Wayne Halbert. They persevered in spite of government bureaucracy, drought and various other problems encountered during the course of this project. Without the patience of these two individuals, this project would not have been successfully completed.

The TSSWCB also sincerely appreciates the patience and cooperation of the agencies involved in this project. Specifically, the TSSWCB would like to thank the Southmost Soil and Water Conservation District (SWCD) for locating the demonstration sites, for coordinating the water quality sampling activities of the demonstration sites and for their involvement in the project-related educational activities. The TSSWCB is also very thankful for the work that Natural Resource Conservation Service (NRCS) completed in this project. Specifically, Tony Gonzales and Allan Moore have worked closely with the Southmost SWCD and assisted them in completing project tasks and also provided technical assistance to the cooperators during the best management practice (BMP) planning and implementation phases of the project. Guy Fipps at Texas Agricultural Extension Service (TAEX) and other TAEX staff did an excellent job on the technology transfer and educational activities. Their efforts are commendable. Lastly, and certainly not least, the TSSWCB would like to thank the staff at Texas Institute for Applied Environmental Research (TIAER), especially Larry Hauck, Joan Flowers, Nancy Easterling and Mark Murphy, for their diligence in analyzing water samples, modeling the effects of the implemented BMPs and completing this final report. The TSSWCB is always pleased with the high quality performance of TIAER.

# SUMMARY

This section 319(h) project was designed to promote the adoption of best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the Arroyo Colorado study area. The project was funded by the U.S. Environmental Protection Agency through Texas Natural Resource Conservation Commission (TNRCC) and Texas State Soil and Water Conservation Board (TSSWCB), with some matching funding for mathematical modeling efforts provided by Texas Water Development Board. Project participants included the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Southmost Soil and Water Conservation District (SWCD), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. Primary tasks of the project included the establishment of coordinating committees, the installation of BMPs and monitoring of demonstration sites, mathematical modeling of the study area, and education and technology transfer.

The project's advisory committees selected BMPs appropriate for crops grown in the study area. Demonstration sites for the project were implemented with BMPs and were monitored over a fifteen-month period for water quality parameters. A multi-layer GIS database for the study area was assembled as part of the mathematical modeling efforts, which also used data collected from demonstration sites. Average annual loads of nutrients and pesticides were estimated for the study area based on the modeling results for the six BMPs listed below:

1. improved nutrient management,
2. improved residue management,
3. improved irrigation water management,
4. improved irrigation technology,
5. irrigation land leveling/precision land forming, and
6. integrated pest management.

The project accomplished several important objectives:

- Improved nutrient and residue management, irrigation land leveling/precision land forming, crop rotation and integrated pest management were demonstrated through implementation on two demonstration sites. Effectiveness of BMP implementation was evaluated though edge-of-field monitoring at the demonstration sites.
- Mathematical modeling efforts, calibrated with monitoring data from the demonstration sites, indicated that substantial reductions in nutrient and pesticide loadings would be achieved from BMP implementation within the study area.
- Exchange of information with agricultural interest groups was promoted through numerous education and technology transfer activities that had a cumulative attendance exceeding one thousand.
- An Internet site was established which contains environmental information and research data, plus agricultural management guides pertinent to the study area.
- Five publications and a videotape which supply information useful to agricultural producers in reducing nutrient and pesticide loadings to the watershed were produced and made available to area agricultural producers.

# ADMINISTRATIVE HISTORY OF THE PROJECT

| *Date* | *Action* |
|---|---|
| May 25, 1994 | TNRCC contract with the TSSWCB for the FY92 Arroyo Colorado Project was executed, project period April 15, 1994 through August 31, 1996. |
| August 2, 1994 | TSSWCB executed subcontract with TAEX. |
| August 24, 1994 | TSSWCB executed subcontract with TIAER. |
| September 9, 1994 | TSSWCB executed subcontract with NRCS. |
| October 12, 1994 | TSSWCB executed subcontract with the Southmost SWCD. |
| April 7, 1995 | TSSWCB submitted contract amendment revising the project workplan and budget and extending the project throughout August 31, 1997. |
| July 13, 1995 | TSSWCB submits draft QAPP to TNRCC. |
| August 28, 1995 | TNRCC submits formal letter request for contract amendment. |
| September 8, 1995 | TNRCC sent comments on the QAPP to be addressed by the TSSWCB. |
| October 4, 1995 | EPA approves workplan and budget changes in letter to TNRCC. |
| November 22, 1995 | TSSWCB made revisions to the QAPP and resubmitted it to TNRCC. |
| November 30, 1995 | QAPP approved by TNRCC and submitted to EPA. |
| February 5, 1996 | QAPP approved by EPA. |
| November 27, 1996 | TNRCC submits to TSSWCB the revised contract amendment for signatures. |
| December 10, 1996 | TSSWCB executed subcontract with TAEX to extend project to August 31, 1997. |
| December 16, 1996 | TSSWCB executed subcontract with TIAER to extend project to August 31, 1997. |
| January 16, 1997 | TSSWCB executed subcontract with NRCS to extend project to August 31, 1997. |
| January 24, 1997 | TSSWCB executed subcontract with Southmost SWCD to extend project to August 31, 1997. |
| June 24, 1997 | QAPP annual revision sent to TNRCC. |

# FINAL REPORT: TABLE OF CONTENTS

# INTRODUCTION

The Arroyo Colorado watershed, located in the coastal border region of southern Texas, has experienced numerous water quality problems in recent years. Evidence points to agriculture, a primary industry of the area, as one possible source of the pollution. This Clean Water Act section 319(h) project serves to demonstrate best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the study area, to promote their adoption among area producers, and to estimate the effects of BMP implementation on local water quality.

The project was developed by the Texas Natural Resource Conservation Commission (TNRCC), Texas State Soil and Water Conservation Board (TSSWCB) and the Southmost Soil and Water Conservation District (SWCD). Cooperating agencies include the Texas Agricultural Extension Service (TAEX), Natural Resources Conservation Service (NRCS), and Texas Institute for Applied Environmental Research (TIAER). This project addresses the impact of nonpoint source pollution resulting from agricultural sources, while the TNRCC has developed a companion project addressing nonpoint source pollution resulting from urban runoff to the Arroyo Colorado. In addition to the cooperating agencies, local citizens and technical experts were involved with the project through coordinating committees established early in the project to provide guidance for research and educational activities.

The overall objective of the project was to promote the adoption of BMPs to abate nonpoint source pollution from agricultural sources in the study area. Specific objectives of this project include the following:

- demonstrate improved nutrient and pesticide management practices;
- evaluate the effectiveness of selected BMPs through monitoring of edge-of-field losses, both surface and subsurface, at the demonstration sites;
- estimate the environmental benefits of widespread BMP implementation through the use of mathematical models to predict pollutant load reductions from agricultural enterprises in the study area; and
- promote increased cooperation and exchange of information between agricultural interest groups through the technical advisory committee and the local advisory committee.

Two fields were selected for implementation and demonstration of BMPs suitable to the study area; one employed dryland cropping practices while the other was irrigated. To evaluate the effectiveness of selected BMPs in abating nonpoint source pollution associated with agricultural drainage, each field was divided into a control section managed according to conventional practices and a treatment section utilizing improved management practices. Samples of surface runoff and subsurface drainage were collected from the control and treatment sections of the fields for chemical analyses. Subsequent modeling analysis of best management practices within the Arroyo Colorado study area applied the Environmental Policy Integrated Climate (EPIC) model to estimate the effects of BMP implementation throughout the study area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application.

# PROJECT ACCOMPLISHMENTS BY TASK

## TASK 1. Establish and Sustain Technical Advisory and Local Advisory Committees

### Subtask 1.1

***TSSWCB and the Southmost SWCD with assistance from NRCS, TAEX, and TIAER will work in concert with TNRCC to sustain a Local Advisory Committee and a Technical Advisory Committee.***

The Local Advisory Committee (LAC) and the Technical Advisory Committee (TAC) for the Arroyo Colorado project were formed in 1994, with meetings of the TAC continuing through 1997. Thirty people formed the LAC, including local citizens, local officials, irrigation district representatives, local agricultural producers, members of local environmental conservation organizations, plus representatives of national agencies and organizations. Twenty-two people formed the TAC, including representatives of the Environmental Protection Agency, Texas State Soil and Water Conservation Board, Texas Natural Resource Conservation Commission, and project participants.

### Subtask 1.2

***TSSWCB and TNRCC will assure that the LAC and TAC are informed of and have an opportunity for input into all aspects of the project through regularly scheduled meetings.***

The LAC and TAC took part in project activities, participating in location of project demonstration sites, determination of boundaries for the study area for modeling efforts, selection of potential BMPs for implementation, recommendations for equipment purchase/maintenance and establishing the need for additional data.

### Milestones

***Establish Technical and Local Advisory Committees.***

Both of these committees were formed in 1994.

### Deliverables

***Minutes of TAC and LAC committee meetings to be attached to quarterly reports.***

Minutes were attached to quarterly reports as requested.

***List of TAC and LAC members.***

Lists of committee members are included in Appendix A.

***Attendance list of TAC and LAC meetings.***

Attendance lists are also included in Appendix A.

## Measure of Success

***Interagency cooperation and coordination at the district level through regularly scheduled TAC and LAC meetings.***

Project participants cooperated appropriately with TAC and LAC during the project. All meetings were held in the area, with the exception of one TAC meeting in Austin. The cooperation among committee members and project participants supported modeling and sampling efforts.

# TASK 2. Identify, Design and Install Two Demonstration Sites

## Subtask 2.1

***Identification of two demonstration sites.***

One demonstration site was located on 60 acres of dryland cropland in Cameron County. This demonstration site had a control field with conventional practices and an adjacent treated field on which BMPs were implemented. The second demonstration site occupied 40 acres of irrigated cropland in Cameron County. This site was selected to take advantage of existing water quality data collected from the site by the Southmost SWCD and NRCS in 1992-93 which could be used as the control data. Although an adequate amount of water quality data had been collected on the site, no accompanying flow data were obtained. Therefore, counter to the original plan, the 40 acre site was divided to provide a control field along with a treated field.

## Subtask 2.2

***Design and installation of BMPs for treated fields.***

NRCS coordinated the design and installation of BMPs with assistance from the Southmost SWCD and TSSWCB. TAEX and NRCS provided technical assistance in BMP application. NRCS utilized data from the automated weather station to assist with scheduling of irrigation and nutrient management. TAEX provided additional technical assistance in nutrient and pesticide management. Nutrient management, pesticide management, residue management, and precision land forming were the BMPs implemented on the dryland treatment field. Nutrient and pesticide management were implemented on the irrigated treatment field. In addition, a subterranean drain tile system and land leveling had previously been implemented on the irrigated site.

## Milestones

***Preparation of a detailed plan for the two demonstration sites.***

Members of the TAC and project participants surveyed BMPs to determine those appropriate for the demonstration sites. NRCS and Southmost SWCD met with site owners several times prior to their September 28, 1995 meeting which finalized the BMPs to be installed on the two demonstration sites. Additional plans for the sites included the following factors:

- Hydrologic isolation of sites by construction of perimeter berms,
- Installation of automatic water samplers in subterranean drain tile system,

- Installation of weather station at demonstration site,
- Precision land forming,
- Soil sample collection and analysis,
- Nutrient management recommendations for plants based on soil analysis,
- Pesticide management based on prevailing field conditions, as determined by scouting professionals,
- Surface irrigation data recommendations based on location, crop, soil type, curve number, irrigation system type and design efficiency,
- Residue management/conservation tillage recommendations based on percent surface cover and timing within the annual crop cycle.

***Presentation of the plan to LAC for input.***

Project participants updated members at all LAC meetings regarding BMP characteristics and the status of BMP implementation at the demonstration sites.

***Install BMPs on treated fields.***

The BMPs were successfully implemented on the demonstration sites in 1996.

## Deliverables

***Quarterly and annual reports.***

Project reports have been submitted throughout the term of the project.

## Measure of Success

***Establishment of two treated fields exhibiting reductions in pesticide and nutrient loading after BMP implementation.***

The two fields implemented with BMPs have been established as described above.

# TASK 3. Evaluate BMP Effectiveness

## Subtask 3.1

***Literature review of existing water quality data in the Arroyo Colorado watershed and of current technology for applicable BMPs. The water quality data for stream segment 2202 will be compiled into a Paradox database. At the conclusion of this project, this data will be stored at the TSSWCB and will be available to the public and other governmental agencies upon request.***

The literature review completed by TAEX, included in Appendix B, contains a comprehensive survey of water quality problems within stream segment 2202 of the Arroyo Colorado Watershed. Current technology for applicable BMPs is presented within the educational materials prepared by TAEX, which are also found in Appendix B. Existing water quality data has been compiled into a Paradox database and is available on the Internet at **http://arroyo.tamu.edu/arroyo/database.html**.

## Subtask 3.2

***Quality Assurance Project Plan (QAPP) for the demonstration sites.***

TSSWCB coordinated the design of the QAPP with the Southmost SWCD, NRCS and TIAER. Appendix C contains a copy of the final copy of the project QAPP, with a letter indicating its approval by EPA. A copy of the TSSWCB audit of the TIAER laboratory is included as Appendix D.

## Subtask 3.3

***Purchase and installation of monitoring equipment, collection of samples, and laboratory analysis of samples will be completed.***

Water quality monitoring equipment was procured by the Southmost SWCD. TAEX and NRCS worked with the Southmost SWCD in installing the monitoring equipment. Sample collection from the demonstration sites was provided by Southmost SWCD. Laboratory analyses of the samples were completed by TIAER. Laboratory data from analyses of samples are included as Appendix E. Weather data collected from the dryland demonstration site is available upon request from Dr. Guy Fipps at Texas Agricultural Extension Service and will soon be available on the Arroyo Colorado Water Quality Web Site. Weather data collected from the city of Harlingen are found on the Texas ET (evapotranspiration) Network and Web Site at **http://www.agen.tamu.edu/pet.** Other sections on this web site provide information on how to use the data for determining proper irrigation scheduling.

## Subtask 3.4

***Evaluation and interpretation of the monitoring data collected from the demonstration sites. The interpretation of the monitoring data will include simple statistical tests and trend analysis.***

Evaluation and interpretation of the monitoring data are included in the final report prepared by TAEX which is provided in the first section of Appendix B. This report also describes additional project activities completed by TAEX.

## Subtask 3.5

***Application of mathematical models to demonstration sites and agricultural regions of the study area. The agricultural portion of the study area will be separated into categories based on soil type, crop, and farming practices (dryland or irrigation). Individual simulations will be performed for each grouping, which will then be aggregated into a representative picture of the agricultural portion of the study area. Simulations will be performed to estimate changes in edge-of-field loading for scenarios with and without BMPs.***

TIAER has applied the Environmental Policy Integrated Climate (EPIC) mathematical model to the demonstration sites and to agricultural regions of the study area. Data describing the study area have been incorporated into TIAER's GRASS geographic information system. Data layers include soil type, land use/vegetative cover, topographical information, monitoring wells, and geographic/cartographic features. Baseline conditions in the study area were characterized. Simulations were run, using various combinations of BMP implementation, to estimate loading reductions from BMP usage.

## Subtask 3.6

***Determine the impact of BMPs on agricultural contributions to nonpoint source pollution by evaluating the viability of various BMPs. The improvements to water quality in the Arroyo Colorado through appropriate BMP implementation will be estimated.***

TIAER prepared a report (Appendix F) detailing the water quality issues in the study area, informational requirements for the model, the geographic information system and climate database. The report also describes the demonstration sites, the water quality monitoring, baseline conditions, the evaluated BMPs, model selection, calibration and sensitivity analysis, and the results from the model evaluation of BMP implementation in the study area. Section 3.4 of the report details the baseline conditions of the study area; section 3.5 describes the BMPs evaluated by the model; and section 5.0 presents the results of the modeling analyses. Table 14, on page 40 of the report, enumerates the percent change estimates associated with BMP implementation in the Arroyo Colorado study area. In addition, TAEX has evaluated the water quality data associated with BMP implementation on the project sites. These evaluations are found in Section 1 of Appendix B.

## Milestones

***Draft Quality Assurance Project Plan to TNRCC and EPA.***

The draft QAPP was completed by TSSWCB, in coordination with TIAER, TAEX, NRCS, and SWCD. It was sent to the TNRCC in July 1995.

***Final Quality Assurance Project Plan approved by TNRCC and EPA.***

EPA granted final approval of the QAPP in February 1996. The approved QAPP was updated and submitted to TNRCC in June 1997 and then submitted to EPA.

***Conduct literature review and compile existing water quality data.***

The literature review is included in Appendix B. This review is available on the Internet for agency personnel and the general public at the following address: **http://arroyo.tamu.edu/arroyo/progrept.html**. TAEX has produced the Arroyo Colorado Water Quality Data Base Web Site at **http://arroyo.tamu.edu**. This web site provides details on the substances analyzed and maps showing the locations of all monitoring stations.

***Complete project design/ Install monitoring equipment.***

The project design was completed and monitoring equipment was installed by NRCS representatives on both demonstration sites in 1996. The criteria used by the LAC and TAC to identify and select BMPs for implementation included the ability to reduce/prevent NPS pollution, low operating costs and favorable regard from the local agricultural community.

***Initiate and complete routine sampling.***

Southmost SWCD representatives have completed water quality sampling at the demonstration sites. In addition, laboratory analyses of the samples have been completed by TIAER. TIAER's laboratory data are included as Appendix E.

***Review monitoring data with LAC.***

The historical water quality monitoring data were presented to the LAC during the January 26, 1995 meeting.

## Deliverables

*Paradox Database.*

TAEX's water quality database, formatted with Paradox software, is available on the Internet at the following address: **http://arroyo.tamu.edu/arroyo/database.html.**

*Draft and Final Quality Assurance Project Plan approved by TNRCC and EPA.*

The final QAPP for this project is attached as Appendix C.

*Report on evaluation of existing water quality data.*

TAEX's evaluation of existing water quality data is included in Appendix B.

*Quarterly and annual reports.*

TSSWCB has submitted project reports through TNRCC to EPA throughout the duration of the project.

*Draft and Final reports on modeling results and BMP effectiveness.*

BMP effectiveness in reducing agricultural contribution to nonpoint source pollution was estimated through application of mathematical modeling and is provided in a report by TIAER (Appendix F).

## Measures of Success

*Quantify load reduction in pesticide and nutrient contributions from agricultural runoff and sub-surface drainage from the demonstration sites.*

Load quantification from the demonstration sites was not possible due to lack of sufficient flow data. Both flow meters at the dryland site and the flow meter at the irrigated treatment site were not functioning properly, resulting in collection of flow data only from the control area of the irrigated demonstration site. The flow meter at the irrigated control site collected data during the first two irrigation events, then malfunctioned. Southmost SWCD purchased and NRCS installed new flow meters near the end of the project, but no samples were collected after their installation. Although loads cannot be calculated without flow data, TIAER was able to use the existing flow data to calibrate the model and predict load reductions for the study area through mathematical modeling.

# TASK 4. Education and Technology Transfer

***This task will emphasize an increased awareness of the problems and solutions associated with nonpoint source pollution from agricultural communities. The transfer of technology to agricultural communities as well as other interest groups and state and federal agencies will be a multi-faceted approach and will be ongoing throughout the project period. TAEX will be the lead agency for accomplishing this task. The Southmost SWCD and NRCS will assist in this task by participating in the educational seminars and workshops.***

***This exchange will include educational seminars and workshops, demonstration tours, dissemination of printed material, development of documentary videotape and research papers and available use of mass media. Efforts will also include individual technical assistance provided by the cooperating agencies as well as assistance from the LAC.***

## Milestones

*Provide fact sheets to local community on pesticide/fertilizer usage.*

The fact sheets listed below were produced by TAEX and made available to the local community during seminars. The documents, listed below and included in Appendix B, continue to be available at local NRCS and SWCD offices.

1. *Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley*
2. *Soil Fertility and Fertilizer Management*
3. *Irrigated Grain Sorghum Production*
4. *Calibrating Pesticide Application Ground Equipment-Calibration Guide and Software*
5. *Help Yourself, Help the Environment*

***Produce documentary video of demonstrations.***

The documentary video was produced by TAEX.

***Conduct educational seminars (lectures) for agricultural community.***

The educational seminars and hands-on workshops listed below were conducted by TAEX for the study area's agricultural community. Additional information about them is included in Appendix B.

| | |
|---|---|
| 1995 | Cotton Pre-Plant Clinic |
| 1995 | Conservation Tillage in South Texas (1995) |
| 1995 | Cotton Production and Physiology Workshop |
| 1995 | Lower Rio Grande Irrigation Conference |
| 1996 | Sprayer Calibration Clinic |
| 1996 | Lower Rio Grande Irrigation Conference |
| 1996 | Irrigation Field Day Tour |
| 1997 | Cotton Pre-Plant Clinic |
| 1997 | No-Till Field Day |
| 1997 | Seminar on the Arroyo Colorado |

The seminars listed below were conducted by NRCS and others for the study area's agricultural community.

| | |
|---|---|
| 1996 | No Till Field Demonstration |
| 1996 | Conservation Tillage Field Day |

## Deliverables

***Fact sheets on pesticide/fertilizer usage.***

The following fact sheets were produced for this project and were made available to local agricultural users during the field days. Copies of the fact sheets are included in Appendix B. These materials are also available to the community at local NRCS offices and SWCD.

***Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley.*** Provides information on the appearance, basic biology and management of major pests of cotton and on occasional pests and beneficial organisms in the Lower Rio Grande Valley.

***Soil Fertility and Fertilizer Management.*** Provides a complete guide to fertilizer management, soil fertility, soil testing and interpretation, and nutrient requirements of major crops.

***Irrigated Grain Sorghum Production.*** Provides a complete guide to grain sorghum production including proper nutrient, chemical and irrigation water management.

*Calibrating Pesticide Application Ground Equipment - Calibration Guide and Software.* This publication and software provides a checklist and a complete guide to proper calibration of ground equipment used for applying pesticides and fertilizers.

*Help Yourself, Help the Environment.* Links conservation tillage to water quality and

***Registration list for seminars and workshops.***

***Copies of materials distributed at seminars and workshops.***

***Copies of agendas for seminars and workshops.***

***Copies of press release for seminars and workshops.***

Copies of the deliverables listed above are provided in Appendix G.

***Copies of video for presentation to various interest groups.***

A copy of the TAEX video is provided with this report.

## Measure of Success

***Percent of agricultural community exhibiting an increased awareness of the consequences of their actions with regard to pesticide and fertilizer applications as measured through the list of attendees for each seminar and workshop performed.***

The combined attendance at the seminars and workshops exceeded one thousand, representing a substantial percentage of the agricultural community. NRCS has provided a video monitor in its local office to encourage agricultural users to view videos which present information on environmental/agricultural topics. In addition, fact sheets produced by TAEX and information on the TAEX website remain available to local agricultural producers. These sources should continue to increase the awareness of the agricultural community in the study area.

# TASK 5. Contract Administration

***The TSSWCB will manage the interagency contract from TNRCC as well as prepare and administer subcontracts with the cooperating agencies.***

TSSWCB managed the interagency contract with TNRCC and completed and administered subcontracts with TIAER, TAEX, Southmost SWCD, and NRCS.

***The TSSWCB staff will provide technical assistance to subcontractors as needed throughout the grant period relative to all aspects of work plans.***

All necessary technical assistance to subcontractors was provided throughout the grant period.

## Milestones

***Contracts with cooperating agencies in place.***

All contracts with cooperating agencies were completed.

***Quarterly reports and draft annual reports to EPA through TNRCC.***

Reports have been submitted to EPA through TNRCC.

***Final reports to EPA through TNRCC.***

This report represents the project's final report.

***Technical assistance as needed.***

Technical assistance has been provided to subcontractors as needed.

## Deliverables

***Quarterly, annual and final reports.***

This report represents the only report remaining to be submitted to EPA through TNRCC.

## Measure of Success

***Provide technical and contractual guidance to the cooperating agencies to assure a successful project.***

Technical and contractual guidance have been provided as evidenced by the successful completion of this project.

# APPENDIX A

## List of Technical and Local Advisory Committee Members; Meeting Attendance Lists

# LOCAL ADVISORY COMMITTEE

| | | |
|---|---|---|
| Pete Wright<br>USDA-NRCS | Jim Chapman<br>Sierra Club | Larry Ditto<br>U.S. Fish & Wildlife Service |
| Rose Farmer<br>National Audobon Society | Jim Gamble<br>Independent producer | Noe Garza<br>D.C. – NRCS |
| Tony Gonzales<br>D.C. – NRCS | Alan Moore<br>Engineer – NRCS | Rick Guerrero<br>local citizen |
| Wayne Halbert<br>Harlingen Irrigation District | Ken Jones<br>Lower Rio Grande Development Council | Terry Lockamy<br>County Extension Agent |
| James Matz<br>Cameron Co. Comm. | Natalie Prim<br>Harlingen City Manager | Jose Sanchez<br>TDA |
| Billy Mack Simpson<br>local citizen | Bill Thompson<br>Irrigation District Director | Steve Thompson<br>Laguna Atascosa Wildlife Refuge |
| Gary Wagerman<br>TPWD | Gail Rothe<br>TNRCC | Andy Garza<br>TSSWCB |
| Charlie Webster<br>TNRCC | Cloice Coykendall<br>Laguna Atascosa WF Refuge | Linda Koch<br>Coalition to Save the Arroyo Co. |
| Cloice Whitley<br>Harlingen Waterworks | Lisa Williams<br>The Nature Conservancy | David Meinhart<br>Harlingen Proud |
| Selena Carroll<br>The Nature Conservancy | Elaine Lockhart<br>Harlingen Proud | Doyle Warren<br>TAES |

## TECHNICAL ADVISORY COMMITTEE

Carl Hutcherson
EPA

Dick Respess
TNRCC

Kerry McCollough
TNRCC

Wayne Halbert
Harlingen Irrigation District

Bo Spoonts
TSSWCB

Ron Jones
TIAER

Allan Colwick
NRCS

Justin Hester
TSSWCB

Guy Fipps
TAEX

Larry Hauck
TIAER

Tony Gonzales
D.C. – NRCS

Terry Lockamy
TAEX

Doyle Warren
TAEX

Arthur Talley
TNRCC

Len Pardee
EPA

Petra Sanchez
EPA

Bill Harris
TAES

Alan Moore
Engineer – NRCS

Lennie Winkelman
TSSWCB

Stormy Sparks
TAEX

James Ratteree
EPA

Kelvin Moore
TNRCC

**Agenda**
**FY92 319(h) Projects on Assessing Nonpoint Source Pollution**
**in the Arroyo Colorado River Watershed**
**Local Coordinating Committee Meeting**
**Harlingen Chamber of Commerce**
**September 22, 1994**
**7:00 PM**

**Mission Statement:** The Local Coordinating Committee (LCC) will provide liaison services between the Technical Advisory Committee and the citizens of Cameron County and other surrounding counties in addressing nonpoint source pollution in the Arroyo Colorado River watershed. Specifically, the LCC will provide guidance concerning the historical effects of tested agricultural and urban practices to the managers and scientists involved in this program and assist in developing best management practices to be used by the local community.

I. Introductions

II. Overview of CWA, Section 319 (h) - Gary Fisher, Texas Nonpoint Source Project Officer, U.S. Environmental Protection Agency, Region 6

III. Overview of the FY92 319(h) Grant - Kerry McCullough, Grant Manager, Texas Natural Resource Conservation Commission (TNRCC)

IV. TNRCC role in project management and discussion of the urban project - Dick Respess, Project Manager, TNRCC

V. Texas State Soil and Water Conservation Board (TSSWCB) role in project management and introduction of subcontractors - Bo Spoonts, Director of Programs, TSSWCB

   a. Larry Hauck, Research Scientist, Texas Institute for Applied Environmental Research
   b. Guy Fipps, Associate Professor and Extension Specialist, Texas Agricultural Extension Service
   c. Alan Moore, Civil Engineer, Soil Conservation Service
   d. Wayne Halbert, District Director, Southmost Soil and Water Conservation District

VI. Discussion with the Local Coordinating Committee (LCC) on a proposed site and election of a Chair and Co-chair for the LCC.

VII. Future actions

September 27, 1994

MEETING MINUTES
of the
Local Coordinating Committee Meeting
FY92 319 (h) Projects on Assessing Nonpoint Source Pollution
in the Arroyo Colorado River Watershed
Harlingen Chamber of Commerce
September 22, 1994
7:00 PM

7:05 PM - Meeting convened by Bo Spoonts, Director of Programs, TSSWCB.

7:05-7:10 PM - Personal introductions were made and a sign-up sheet was passed around.

7:10-7:15 PM - Gary Fisher, Texas Nonpoint Source Project Officer from EPA, gave an overview of Section 319 funding. Gary gave EPA's definition of nonpoint source pollution and explained the mechanism of the 319 funding. He said that on the Arroyo Colorado project funds came from EPA to TNRCC to TSSWCB to Subcontractors. He also said that TNRCC was handling the urban side while TSSWCB was handling the agricultural aspect of the project. Gary stressed how we need a Local Coordinating Committee (LCC) to meet the success of the project.

Gary introduced Carl Hutcherson who is the new liaison between SCS and EPA.

Gary then introduced Kerry McCollough of TNRCC who was next on the agenda.

7:15-7:16 PM - Kerry McCollough, TNRCC Grant Manager, explained how the Arroyo Colorado project bridges agricultural and urban problems in the Arroyo Colorado River watershed. The knowledge and BMP's learned from this project can be transfered to other local counties.

Kerry introduced Dick Respess, TNRCC Project Manager on the urban side of the project.

7:16-7:34 PM - Dick Respess said that urban landscaping is a significant contributor to nonpoint source pollution. Dick showed and explained many overheads as listed below:

Overhead #1 - Integrated Landscape Management (ILM)
 Explained soil moisture, soil nutrient concentration, and vegetation health
Overhead #2 - Arroyo Colorado Nonpoint Source Project
 Explained the benefits of ILM of reducing landscape maintenance costs and nutrient/pesticide loadings
Overhead #3 - Goals and Objectives

Reduce nutrient loadings, provide training to landscape managers, and increase public awareness

Overhead #4 - Project Tasks

Planning, implementation, and technology transfer

Dick said that the urban project was to be done on the Tony Butler Golf Course and passed out a copy of the urban project workplan.

Dick then gave the floor back to Bo Spoonts.

7:34-7:44 PM - Bo explained the difference between TNRCC and TSSWCB's role in the project and gave several examples of nonpoint source pollution - cigarette butts on ground, gasoline fumes, oil on a driveway, etc. He said that there was no way to completely stop nonpoint source pollution but it could be slowed down.

Bo then explained that in the workplan there are two (2) sites to be studied: A dryland cropland, and an irrigated cropland site.

Bo introduced Larry Hauck, Research Scientist, Texas Institute for Applied Environmental Research.

7:44-7:46 PM - Larry said that TIAER brings two (2) areas of expertise to the project. The first area of expertise is the chemistry laboratory analyses to study nutrient and bacterial concentrations of Arroyo Colorado River water samples. The second is numerical modeling to predict agricultural run-off of the fields chosen.

Bo then introduced Guy Fipps, Associate Professor, Texas Agricultural Extension Service.

7:46-8:01 PM - Guy Fipps gave an gave a presentation on several overheads which are attached.

Bo introduced Alan Moore, Soil Conservationist, Soil Conservation Service, San Benito.

8:01-8:06 PM - Alan explained the mechanism of the SCS within the USDA. SCS's responsibility is to provide technical assistance to the landowners in installing best management practices. SCS takes a voluntary, non-regulatory approach to assisting landowners. On this particular project, SCS will install and monitor the equipment on the two (2) sites chosen.

Bo introduced Wayne Halbert, Harlingen Irrigation District Director, and Director of the Southmost Soil and Water Conservation District.

8:06-8:12 PM - Wayne said the purpose of the Southmost SWCD is to deal with local soil and water conservation issues. This project originated in 1989 and is finally starting to try to implement BMP's to show nonpoint source pollution improvement. Wayne told the

LCC not to waste the opportunity to work on this important project to make a difference in the community. He stressed how the LCC can influence the success of the project by selling it to the local community.

8:12-9:00 PM - Bo had the LCC look at establishing and sustaining an active coordinating committee as an important aspect of the workplan. Bo also explained the difference between the LCC and Technical Advisory Committee (TAC).

Wayne Halbert intervened to say that there are not two (2) distinct projects - urban and agricultural. The major impact was to better the water quality in the Arroyo Colorado.

Bo asked the LCC if they would like to elect a Chair and Co-chair on the LCC to be the liaison between the LCC and the Technical Advisory Committee. No response from the LCC.

Dick Respess said that the urban side of the project would be done on the Tony Butler Golf Course.

Bo said that the agricultural irrigated site is located near Harlingen and already instrumented. Asked whether any one had any suggestions for the dry land site.

Steve Thompson of the Laguna Atascosa Wildlife Refuge volunteered 150 acres as a controlled monitoring site.

Wayne Halbert said the idea was to take Farms A and B that are the same and install BMP's on Farm A to see if it is improved over Farm B.

Guy Fipps led the discussion back to site selections. He suggested the LCC as a group look at the selection of the 2 sites and respond to the TAC with questions.

Wayne said that the irrigated site was chosen because of money constraints since the equipment has already been installed.

Jim Chapman wanted to know the name of the irrigated site selected or specifics.

Wayne answered him by saying that on the irrigated cropland cotton and grain would be planted on a rotational basis. The dryland site would also be the same.

Steve Thompson asked that if they weren't given the names of the sites selected then are the farmers respected within the community. Bo answered that they were.

Dick Respess reiterated to the LCC that if anyone had any questions on the urban side of the project do not hesitate to call him at TNRCC. He was working on getting the QAPP approved before sampling takes place. Dick also said he would send quarterly reports to the LCC.

Gary Fisher explained the water assessment process. He also stated that EPA's viewpoint is that nonpoint source pollution can and will be abated.

Alan Moore suggested that monitoring on the dryland cropland and the irrigated cropland start in February. This means the QAPP must be submitted by December, 1994.

Terry Lockamy suggested November 17, 1994 as the next meeting date. The LCC agreed that this was a good day and 7:00 PM was a good time.

9:00 PM - Bo adjourned the meeting.

sc

Arroyo Colorado
Local Coordinating Committee Meeting
Harlingen, T

September 22, 1994
7:00 PM

| NAME | Address | Phone No. |
|---|---|---|
| Suzanne Cardwell | TSSWCB | (817) 773-2250 |
| Bo Spoonts | TSSWCB | (817) 773-2250 |
| Richard O. Respess | TNRCC | (512) 239-4550 |
| Gary Fisher | EPA | (214) 665-6685 |
| Carl Hutcherson | SCS/EPA | (214) 665-6685 |
| Kerry McCollough | TNRCC | 512-239-4548 |
| Pete Wright | SCS | 512-664-0903 |
| Alan Moore | SCS - San Benito | 210-399-2522 |
| Steve Thompson | Laguna Atascosa NWR | 210-748-360 |
| Wayne Halbert | Southmost SWCD | 210-423-7015 |
| Kim Soucek | TAMU | 409-847-9797 |
| Guy Fipps | Texas A&M, College Station | 409-845-3977 |
| Larry Hauck | TIAER | 817-968-9561 |
| Billie Mack Simpson | Rio Hondo, Tx | 210-748-2752 |
| Natalie F. Prim | City of Harlingen 118 E. Tyler | 210 427-870 |
| Larry Ditto | FWS | 210 630 4636 |
| Rick Guerrero | Harlingen, TX Ag + Nursery | 210-412-227 |
| Jim Gamble | Rt. 1 Box 73 La Feria 78559 | 210-797-2858 |
| Terry Lockamy | 650 E Hwy 77 San Benito | 210-399-0125 |
| Lisa Williams | The Nature Conservancy 410 N. 13th Ave. - Edinburg, TX 78539 | 210/380-3134 |
| Selena Carroll | The Nature Conservancy address above | 210/380-3134 |
| Jim Chapman | 200 E. 11th St Weslaco | 210 968-1719 |

Arroyo Colorado
Local Coordinating Committee mtg.
Harlingen, TX

September 22, 199
7:00pm.

| NAME | ADDRESS | | PHONE NO. |
|---|---|---|---|
| Linda Koch (Coalition To Save A.C. (C-SAC) | Rt 2, Box 550- San Benito, Tx 78586 | | 210-748-2766 |
| (1) Dave Meinhart Harlingen Road & Volunteer Water Quality | 1325 Dixieland Harlingen 78552 | | 210-428-5881 |
| Doyle G. Warren | 2401 E Hy 83 | Weslaco TX 78596 | 2109685581 |
| Andy Garza | TSSWCB | Falfurrias, Tx. 78355 | |
| José Sanchez TDA | P.O. Box 1157 | Pharr, TX 7857 | |
| Bill Thompson | P.O. Box 867 | Mission, Tx 785 | |
| Noe G Garza USDA-SCS | 2514 S. "I" RD STE 2 EDINBURG TX 78539 | | (210) 383-300 |

# TEXAS STATE SOIL AND WATER CONSERVATION BOARD

311 North 5th
P.O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

To: Local Advisory Committee

From: Lennie Winkelman

Date: February 23, 1995

Subject: Meeting Minutes of Local Advisory Committee Meeting

Enclosed you will find a copy of the attendance list and the minutes from the Local Advisory Committee Meeting held in Harlingen on January 26th.

If you have any question please do not hesitate to contact me.

Sincerely,

Lennie Winkelman

Lennie Winkelman
Planner

January 26,1995

MEETING MINUTES
of the
Local Coordinating Committee Meeting
FY92 319 (h) Projects on Assessing Nonpoint Source Pollution
in the Arroyo Colorado River Watershed
January 26, 1995
7:00 PM

7:05 PM - Meeting Convened by Bo Spoonts, Director of Programs, TSSWCB.

7:05 - 7:10 PM - Personal introductions were made and a attendance sign up sheet was passed around. The attendance sheet is attached.

7:10 - 7:13 PM - Bo Spoonts explained that the role of the Local Coordinating Committee (LCC) is of an advisory nature. The LCC would express concerns and provide feedback about the activities on the project. The LCC's name would be changed to the Local Advisory Committee to more accurately reflect its role.

7:13 - 7:40 PM Dick Respess, TNRCC Project Manager, explained that the urban component of the project would take place at Tony Butler Golf Course. A local engineering firm has been contracted to survey several sites at the golf course. The survey will aid in the placement of the sampling sites. TNRCC has been working with Dr. Fipps at TAEX on stormwater monitoring and integrated landscape management. The staff at the golf course will be trained to help in the sampling. The Quality Assurance Project Plan has been submitted to the TNRCC and is awaiting approval before sampling can begin. In March, the stormwater monitoring equipment and BMP's should be installed so that sampling can begin. Samples will be taken at a demonstration site with BMP's and at natural site without BMP's. The urban component will mainly look at nutrients.

Someone questioned why the TNRCC removed pesticides from the study. Dick responded that previous assessments indicated that nutrients were the main problem.

Wayne Halbert stated that the original idea of the project was not to determine what urban and agriculture pollution contributed to the Arroyo Colorado. These projects are demonstrations that are used as land management practices to control pollution runoff.

7:40 - 8:12 PM Dr. Fipps from TAEX reported on the water quality database that was compiled on the Arroyo. He contacted various state and federal agencies to collect this data and has received most of the information he requested.

He showed an overhead of the different routine water quality parameters that have been sampled for by different state and federal agencies. Some of these parameters on this overhead were nitrate nitrogen, dissolved oxygen, and several organic and inorganic constituents.

He showed an overhead map of the Arroyo and described where the segments of 2201 and 2202 were located and where previous water samples had been taken.

Finally, he showed an overhead of the water quality data for 1984. He examined the data for this year and stated that none of the samples exceeded the safe water drinking standards. However, he also noted that there was a high fecal coliform count for several of the samples taken in the Arroyo. This could be attributed to the wastewater treatment plants that discharge treated effluent into the Arroyo.

He concluded his presentation by stating that he has examined only a portion of the water quality data that has been compiled. He hopes to go through all of the water quality data and determine if there are trends.

8:12 - 8:20 PM Tony Gonzales from NRCS discussed the two demonstration sites. The irrigated site is 40 acres and has been field leveled.

The dryland demonstration area is on FM 1420 and is 60 acres in size. The site will be divided into two 30 acre tracts with one being a control site and the other implemented with BMPs. The sites will be planted with a crop rotation of cotton and sorghum. Cotton will be planted this spring. there will be no water sampling on the dryland site this spring. The installation of the BMPs will occur this summer and sampling will occur in the fall.

8:20 - 8:23 PM Lennie Winkelman from the TSSWCB discussed the Quality Assurance Project Plan. He has collected information from TIAER on laboratory procedures to include in the QAPP. He is also working with the SWCD and NRCS in compiling the sampling procedures needed to include in the QAPP. He hopes to have a draft QAPP submitted to TNRCC by March 1995.

8:23 - 8:30 PM Bo Spoonts from the TSSWCB asked for suggestion on when the next Local Advisory Meeting should be held. It was decided that the next meeting will be held on May 25, 1995 at 7:00 P.M. at the Harlingen Chamber of Commerce.

8:30 PM The meeting was adjourned.

LW

1/26/95 Arro, 3 Colorado Sign-In sheet

| Name | Address | phone |
| --- | --- | --- |
| Lennie Winkelman TSSWCB | P.O. Box 658 Temple, TX 76503 | (817) 773-2250 |
| Guy Fipps | Texas A&M, College Station | 409 845-3977 |
| Stormy Sparks | Texas Ag. Extension Service, Weslaco | (210) 968-558 |
| Bill Thompson | Hidalgo Soil & Water Dist. | (210) 585-48 |
| Wayne Halbert | SMSWCD PO 148 Harlingen | 210 423-70 |
| Carl Hutcherson | EPA Region 6, 1445 Ross, Dallas | (214) 665-80 |
| Petra Sanchez | EPA Region 6 " " Suite 1200 6W-QS Dallas TX 75202 | " 665-668 |
| Joan Flowers | TIAER - Tarleton State University Box T0410 Stephenville, TX 76402 | (817) 968-9 |
| Doyle G Warren | 2401 E Hy 83 Weslaco Tx 78596 | 210 968 ... |
| Terry Lockamy | 650 E Hwy 77 San Benito Tx 78586 | 210-399 4412 |
| Jim Gamble | Rt. 1 Box 123 La Feria Tx. 78559 | 210-797-2858 |
| Tony Gonzales | Rt. 2 Box 372 San Benito Tx 78586 | (210) 399-2522 |
| Andy Garza | 104 Magnolia, Falfurrias, Tx. 78355 | 512-325-355 |
| Adrian Perez | P.O. Box 345, Freer, Tx 78357 | 512-394-6 |
| Noé G Garza | USDA-NRCS- 2514 S. "I" Rd, Ste 2, Edinburg TX 78539 | (210) 383-3002 |
| Richard O. Respess TNRCC | P.O. Box 13087 Austin, TX 78711 | (512) 239-455 |
| Linda Koch - C-SAC | Rt 2, Box 550 - San Benito, Tx 78586 | (210) 748-3 |
| David W. Smith TAEX | 313 AGEN Dept., College Station, TX. 77843 | (409) 84 5614 |

1/26/95

ARROYO COLORADO TECHNICAL ADVISORY

| | | |
|---|---|---|
| Bo Spoonts | TSSWCB | (817) 773 2250 |
| Lennie Winkelman | TSSWCB | (817) 773-225 |
| Guy Fipps | TAEX | 409 845-395 |
| Terry A. Lockamy | TAEX | 210-399-4412 |
| Nelda Barrera | TAEX | " |
| Doyle G Warren | TAEX | 210 968 5581 |
| LARRY HAUCK | TIAER | 817 968-956 |
| Joan Flowers | TIAER | 817-968-95 |
| WAYNE HALBERT | SMSWCD | 210-423-70 |
| CARL HUTCHERSON | EPA/NRCS | (214) 665-808 |
| Petra Sanchez | EPA | " " -6686 |
| Tony Gonzales | NRCS | (210) 399-2522 |
| Andy Garza | TSSWCB | 512-325-3557 |
| Adrian Perez | TSSWCB | 512-394-6786 |
| Dick Rescorss | TNRCC | (512) 239-4550 |

1/26/95

ARROYO COLORADO TECHNICAL ADVISORY

| | | |
|---|---|---|
| Bo Spoonts | TSSWCB | (817) 773 2250 |
| Lennie Winkelman | TSSWCB | (817) 773-2250 |
| Guy Fipps | TAEX | 409 845-397[illegible] |
| Terry A. Lockamy | TAEX | 210-399-4412 |
| Nelda Barrera | TAEX | " |
| Doyle G Warren | TAEX | 210 968 5581 |
| LARRY HAUCK | TIAER | 817 968-9561 |
| Joan Flowers | TIAER | 817-968-955[illegible] |
| WAYNE HALBERT | SMSWCD | 210-423-7015 |
| CARL HUTCHERSON | EPA/NRCS | (214) 665-8081 |
| Petra Sanchez | EPA | " " -6686 |
| Tony Gonzales | NRCS | (210) 399-2522 |
| Andy Garza | TSSWCB | 512-325-3552 |
| Adrian Perez | TSSWCB | 512-394-6786 |
| Dick Respess | TNRCC | (512) 239-4550 |

**TEXAS STATE SOIL AND WATER CONSERVATION BOARD**

311 North 5th
P.O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

To: Local Advisory Committee

Thru: Dick Respess

From: Lennie Winkelman

Date: May 9, 1995

Subject: Local Advisory Committee Meeting on Arroyo Colorado Project

There will be another meeting of the Local Advisory Committee in Harlingen to discuss the Arroyo Colorado Watershed Project. The meeting will be on May 25th at 7:00 p.m. at the Harlingen Public Library. To get to the Library go West on Tyler and turn left on 6th street. The library is at the end of 6th street on 410 76 Drive.

There are three items on the agenda for discussion.

1) Overview and update of the Urban component of the project
2) Overview and update of the Agricultural component of the project
3) Open Discussion of Arroyo Colorado Watershed Project

Dick and I hope to see you at the meeting. If you have any questions please contact me at (817) 773-2250 or Dick Respess at (512) 239-4550.

Sincerely,

Lennie Winkelman

Lennie Winkelman
Planner, Texas State Soil and Water Conservation Board

Richard O Respess

Dick Respess
Project Manager, Texas Natural Resource Conservation Commission

cc: Technical Advisory Committee

Arroyo Colorado Local

Advisory Committee meeting

5/25/95

| Name | Adress | phone # |
|---|---|---|
| Lennie Winkelman | Texas state soil & water Brd P.O. Box 568 Temple, TX 76503 | (817) 773-225 |
| Gail Rothe | Texas Natural Resource Conservation Comission Austin P.O. Box 13087 | 512-239-4617 |
| LISA WILLIAMS | SOUTH TX. LAND STEWARD PO BOX 6281 THE NATURE CONSERVANCY MCALLEN TX 78502 MC150 | 210/580-4241 |
| Tim Cooper | U.S Fish and Wildlife Service P.O. Box 450 Laguna Atascosa NWR Rio Hondo | 210/748-3607 |
| Albert Ramirez | TSSWCB | 210/381-6614 |
| Wayne Halbert | Southmost SWCD | 210/423-7015 |
| LARRY DITTO | 320 W. MAIN, McAllen Tx 78501 (FWS) | 210/630-4636 |
| Guy Fipps | Texas Agr Extension, Texas A&M | 409 845-7454 |
| Larry Hauck | TIAER, TARLETON STATE UNIV, Stephenville | 817-968-9561 |
| Richard O. Respess | TNRCC, NPS Program, Austin | (512) 239-4550 |
| JOHN LIGHTNER | AGRI-SYNERGETICS, INC. Harlingen | (210)412-2150 |
| Doyle C. WARREN | Tex Ag Ext Serv | 210 968 5581 |
| Merritt J. Taylor | 2401 East Hwy 83, Weslaco, Tx 78596 | (210)-968-5581 |

## REPORT ON ASSIGNED DUTIES

### Local Advisory Committee and a Technical Advisory Committee

Three Local Advisory Committee Meetings were held as listed in Table 1. At these meeting, Guy Fipps, Merritt Taylor, Alton Sparks and Kim Soucek gave presentations on TAEX's role on the project, the potential benefits of recommended BMPs, and what is known about the water quality of the Arroyo Colorado. TAEX also participated in 6 Technical Advisory Committee Meetings. The date, location and TAEX personnel participating are listed in Table 2.

Table 1. Meetings of the Local Advisory Committee and TAEX Project Team Personnel Participating.

| Date | Location | TAEX Team Members Attending |
|---|---|---|
| 9/22/94 | Harlingen | Guy Fipps, Terry Lockamy, Anton Sparks, Kim Soucek |
| 1/26/95 | Harlingen | Guy Fipps, Doyle Warren, Merritt Taylor |
| 5/25/95 | Harlingen | Guy Fipps, Terry Lockamy, Alton Sparks, Merritt Taylor |

Table 2. Meetings of the Technical Advisory Committee and TAEX Project Team Personnel Participating.

| Date | Location | TAEX Team Members Attending |
|---|---|---|
| 7/26/94 | Harlingen | Guy Fipps, Ken Lege, Terry Lockamy, Doyle Warren |
| 9/14/94 | Austin | Guy Fipps |
| 1/26/95 | Harlingen | Guy Fipps, Terry Lockamy, Doyle Warren |
| 9/28/95 | Harlingen | Guy Fipps |
| 9/23/96 | Harlingen | Guy Fipps, Rod Santa Ana, David Smith |
| 4/1/97 | Harlingen | Guy Fipps |

# TECHNICAL ADVISORY MEETING AGENDA ITEMS 9/23/96

I. Update on previous and upcoming educational activities and workshops (TAEX)

II. Update on activities for the irrigated and dryland demonstration sites (John Lightner, NRCS)

III. Update on modeling efforts for the Arroyo Colorado (TIAER)

IV. General discussion of coordination efforts and future activities needed to successfully complete the last year of the project.

NOTE: After the meeting, Guy Fipps from TAEX and a video crew will conduct personal interviews with the various project participants involved with the project.

Attending: Guy Fipps, TAEX, College station + David Smith, asst.
Bo Sprontz, TSSWCB
Lennie Winkleman, TSSWCB
Larry Hauck, TIAER + Asst.
Andy Garza
John Lightner
TNRCC Rep. –

1. Order 2 sets of bottles.
2. Buy 4 new Cambell data loggers. Model CR-10
3. Place rain guage at irg. site
4. Check irrigation flows. in-line flow meter – gated pipe – or polypipe.
5. Check landuses for computer modeling. (Meander to Port Harlingen)
6. Gather agronomic data.
7. Set up for moisture tracking – Andy's office will read the gypsum blocks.
8. A local committee meeting will be scheduled for Nov. 19, 1996.

For: Justin Hester

From: Lennie Winkelman

ARROYO COLORADO TECHNICAL MEETING NOTES 9/23/96

1 sampling event was conducted on the dryland site and several samples have been collected on the irrigated site.

There has also been a problem of vandalism and theft of ISCO batteries on the demo sites.

John Lightner has had problems with access to the irrigated sites because the fields are wet. *Note: Need to remind John that samples must be collected no matter how wet the fields are. If need assistance please ask for help. Andy's office has offered to help with monitoring as needed and time permits.*

Little information has been collected on the irrigation and rainfall amounts for the sites. Dataloggers on the demo sites have not worked effectively for a good portion of the last year. Larry Hauck stated that the dataloggers need to be upgraded. Guy Fipps will provide Info Campbell dataloggers. The State Board should plan on purchasing 4 of the dataloggers.

Cotton will be planted on both sites about February.

## MODELING

TIAER has collected background data and is evaluating several models including: DRAINMOD, EPIC-WT, and EPIC-4160.

Have info on several of the GIS layers including: landuse, soils, monitoring wells, etc. Need to coordinate with NRCS and others on site specific items including: soil types, nutrient and pesticide application dates, amounts, etc.

TIAER will provide Tony a copy of the Land use map for field verification.

Also the project needs to obtain a flowmeter and gated pipes for the irrigated site.

**Educational activities**

Guy Fipps and others are working several fact sheets and guides for irrigation, fertilization, and pesticides.

A conservation tillage workshop will be held in January and a regional seminar will be held in June or July 1997.

The 10 minute informational video is behind schedule and the WQ database was sent to TSSWCB, TNRCC, and EPA.

**NEXT MEETING: NOVEMBER 19TH 3:30 for technical advisory committee and 7:00 local advisory meeting. Can set the meeting at the Chamber of Commerce or Harlingen Library.**

**Also should have quarterly meetings until the end of the project.**

# Arroyo Colorado

## Attendance

| | | |
|---|---|---|
| Bo Spoonts | TSSWCB | Temple, TX |
| Tony Gonzales | NRCS | San Benito |
| John Lightner | AgroSynergetics | Harlingen, TX |
| Alan Moore | NRCS | San Benito |
| Andy Garza | TSSWCB | Harlingen |
| Larry Hauck | TIAER | Stephenville TX |
| Joan Flowers | TIAER | Stephenville, TX |
| Lennie Winkelman | TSSWCB | Temple, TX |
| Kelvin Moore | TNRCC | [illegible] TX |
| David W. Smith | TAEX | College Station, TX |
| [illegible] | [illegible] | |

# APPENDIX B

## Nonpoint Source Prevention in the Arroyo Colorado: Accomplishments of the Texas Agricultural Extension Service

# APPENDIX B

## Nonpoint Source Prevention in the Arroyo Colorado: Accomplishments of the Texas Agricultural Extension Service

# NON POINT SOURCE PREVENTION IN THE ARROYO COLORADO WATERSHED

# ACCOMPLISHMENTS OF THE TEXAS AGRICULTURAL EXTENSION SERVICE

# FINAL REPORT

Submitted to the

Texas State Soil and Water Conservation Board

by

Guy Fipps
Texas Agricultural Extension Service
Texas A&M University System
College Station, TX 77843-2117

November 26, 1997

PREPARED IN COOPERATION WITH THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was 60% financed through $443, 630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission

# Table of Contents

# *Report*

## SUMMARY

This report summarizes the accomplishments of the Texas Agricultural Extension Service (TAEX) on the project ***NPS Prevention in the Arroyo Colorado Project***. Funding for this project was provided by the U.S. Environmental Protection Agency (USEPA). TAEX services were performed under Contract No. 994-592-713-4200000051 to the Texas State Soil and Water Conservation Board (TSSWCB).

Only a summary of our activities are provided here. Detailed accounting has been provided in the form of Quarterly Reports submitted to the TSSWCB during the course of the project. Copies of the educational materials produced by TAEX in this project are provided in the Appendix of this report. The following agencies cooperated on the project:

U.S. Environmental Protection Agency (USEPA)
Texas Natural Resource Conservation Commission (TNRCC)
Texas State Soil and Water Conservation Board (TSSWCB)
Southmost Soil and Water Conservation District (SSWCD)
Natural Resources Conservation Service (NRCS)
Texas Institute for Applied Environmental Research (TIAER)
Texas Agricultural Extension Service (TAEX).

## PROJECT RESPONSIBILITIES

Our major responsibilities on this project were to:

1. Provide assistance to establish a Local Advisory Committee and a Technical Advisory Committee;

2. Provide technical assistance in planning, locating, designing, installing, and evaluating the results of the BMPs (best management practices) implemented for two demonstration sites;

3. Assemble a *PARADOX* data base of existing water quality data on the Arroyo Colorado;

4. Conduct an education and technology transfer program consisting of:

   a) fact sheets,
   b) documentary video, and
   c) educational workshops and seminars; and

5. Provide technical assistance to TIAER in BMP modeling.

## PROJECT TEAM

TAEX assembled a multi-disciplinary team for this project as follows. Dr. Guy Fipps served as the TAEX project director.

*Core Team Members*

| Name | Title |
|---|---|
| Dr. John Bremer | Professor and Extension Weed Scientist |
| Dr. Guy Fipps | Associate Professor and Extension Agricultural Engineer |
| Dr. Steve Livingston | Professor and Extension Agronomist |
| Terry Lockamy | Cameron County Extension Agent |
| John Norman | Extension Entomologist |
| Rod Santa Ana | Extension Communications Specialist |
| Dr. Bryan Shaw | Assistant Professor and Extension Agricultural Engineering Specialist |
| David Smith | Extension Assistant |
| Dr. Alton Sparks | Associate Professor and Extension Entomologist |
| Dr. Charles Stichler | Associate Professor and Extension Agronomist |
| Doyle Warren | District 12 Extension Director |
| Ed Wilson | Extension Graduate Assistant (former) |

*Supporting Team Members*

| Name | Title |
|---|---|
| Brent Batchelor | Atascosa County Extension Agent (former) |
| Carrie Bausch | Student Technician |
| Brad Cowan | County Extension Agent |
| Monty Dozier | Extension Graduate Assistant |
| Ken Lege | Extension Associate (former) |
| Dr. Bruce Lesikar | Assistant Professor and Extension Agricultural Engineering Specialist |
| Dr. Mark McFarland | Assistant Professor and Extension |
| Luis Saldana | Willacy County Extension Agent |
| Dr. Julian Sauls | Professor and Extension Horticulturist |
| Kim Soucek | Student Technician (former) |
| Dr. Merritt Taylor | Professor and Extension Economist (former) |

## REPORT ON ASSIGNED DUTIES

### Local Advisory Committee and a Technical Advisory Committee

Three Local Advisory Committee Meetings were held as listed in Table 1. At these meeting, Guy Fipps, Merritt Taylor, Alton Sparks and Kim Soucek gave presentations on TAEX's role on the project, the potential benefits of recommended BMPs, and what is known about the water quality of the Arroyo Colorado. TAEX also participated in 6 Technical Advisory Committee Meetings. The date, location and TAEX personnel participating are listed in Table 2.

Table 1. Meetings of the Local Advisory Committee and TAEX Project Team Personnel Participating.

| Date | Location | TAEX Team Members Attending |
|---|---|---|
| 9/22/94 | Harlingen | Guy Fipps, Terry Lockamy, Anton Sparks, Kim Soucek |
| 1/26/95 | Harlingen | Guy Fipps, Doyle Warren, Merritt Taylor |
| 5/25/95 | Harlingen | Guy Fipps, Terry Lockamy, Alton Sparks, Merritt Taylor |

Table 2. Meetings of the Technical Advisory Committee and TAEX Project Team Personnel Participating.

| Date | Location | TAEX Team Members Attending |
|---|---|---|
| 7/26/94 | Harlingen | Guy Fipps, Ken Lege, Terry Lockamy, Doyle Warren |
| 9/14/94 | Austin | Guy Fipps |
| 1/26/95 | Harlingen | Guy Fipps, Terry Lockamy, Doyle Warren |
| 9/28/95 | Harlingen | Guy Fipps |
| 9/23/96 | Harlingen | Guy Fipps, Rod Santa Ana, David Smith |
| 4/1/97 | Harlingen | Guy Fipps |

## BMPs and Demonstration Program Support

Demonstration Sites and BMPs

The TAEX Project Team met on August 29-30, 1995 to tour the demonstration sites and to formulate detailed recommendations on BMP design, implementation and evaluation. These recommendations were based on the limited amount of information made available to us on the sites and demonstration program planned. Our conclusions were summarized in a report submitted to TSSWCB on 9/14/97. A copy of this report is provided in Appendix A.

Direct technical assistance was provided to NRCS by Guy Fipps and Ed Wilson on instrumentation, data logging programing, and equipment installation, and through informal discussions on BMPs. No other assistance was requested of TAEX during the remainder of the project.

We also provided technical assistance to NRCS on programming, maintenance and management of the weather station located at the dryland demonstration site. This weather station was included on the ***Texas ET (evapotranspiration) Network and Web Site (http://www.agen.tamu.edu/pet)***. We downloaded the weather data daily, calculated PET, and posted this information on the Web Site. Other sections on the Web Site provided information on how to use this data for determining proper irrigation scheduling. This assistance and project support was provided by Guy Fipps and his WQIT project team (see web site for complete listing of team members).

Evaluation of Demonstration Results

TIAER provided us with diskette and printed copies of the water sample analysis results taken from the demonstration sites on 7/23/97 (all data except for June 1997) and on 8/1/97 (all data). A paper copy of this data is given in Appendix B. We received very little information on the BMPs implemented over the course of the project, and TSSWCB provided us a summary of these (Table 3) in September 1997.

We were not able to do statistical tests and trend analysis of the monitoring data due to the limited amount and inconsistency of the data, and experimental errors in the establishments of the sites. Instead, we completed a qualitative analysis of BMP benefits which are summarized in Tables 4 and 5. For these tables, we made a judgement whether there was evidence of benefits from the BMP's for each parameter analyzed.

For the irrigated site, the BMPs resulted in reductions in the following substances in one or more sampling events: ammonia nitrogen, nitrite nitrogen, total phosphorous, atrazine, malathion, and trifluraline. The reductions in total suspended solids is probably due to either experimental or sampling errors, as we would expect no differences in drain water suspended solids between the two treatments.

For the dryland site, the BMPs resulted in reductions in the following substances in one or more sampling events: nitrite nitrogen, total kjeldahl nitrogen, total suspended solids, COD, atrazine, and malathion.

Table 3. BMPs Implemented on the Irrigated and Dryland Demonstration Sites.

| |
|---|
| Irrigated Site: |
| • Crop rotation |
| • Conventional tillage system - the producer left 25% of the stubble during fallow period (crop residue management) |
| • Nutrient management — split application of fertilizer and application based on soil analysis |
| • Pesticide management — the producer had a scout from the chemical company advise him on whether or not to apply pesticides for insects. For both insect and weed control, the producer follows the label directions. Pesticides are applied at optimum wind conditions. |
| Dryland Site: |
| • Crop rotation |
| • Conservation tillage |
| • Precision-land farming (land leveling) |
| • Nutrient and Pest Management |

Table 4. Irrigated Demonstration Site: BMP Effectiveness in Reducing Concentrations in Drainage Water

| Substance | Event | | | | | |
|---|---|---|---|---|---|---|
| | #1 | #2 | #4 | #5 | #6 | #7 |
| Ammonia Nitrogen | yes | no | yes | no | no | no |
| Nitrate Nitrogen | no | no | no | no | -- | yes |
| Nitrite Nitrogen | yes | yes | no | no | -- | -- |
| Total Kjeldahl Nitrogen | no | no | no | no | -- | -- |
| Orthophosphate Phosphorus | no | no | no | yes | -- | -- |
| Total Suspended Solids | yes | -- | yes | yes | yes | yes |
| Total Phosphorus | yes | no | no | no | -- | -- |
| Chemical Oxygen Demand | no | no | no | no | -- | -- |
| Atrazine | yes | no | no | no | -- | -- |
| Azinphos | -- | -- | no | -- | -- | X |
| Malathion | -- | -- | no | yes | -- | -- |
| Parathion | -- | -- | -- | -- | -- | -- |
| Permethrin | -- | no | no | no | no | -- |
| Prometryn | -- | -- | -- | -- | -- | -- |
| Trifluralin | yes | -- | -- | no | no | no |

Footnotes:

Irrigation Sampling Events

| Event | Description |
|---|---|
| #1 | 4/12-14/96, grain sorghum, post-irrigation, 30-60 hours, control 4/13-15/96, 60-80 hours |
| #2 | 5/14/96, grain sorghum, post-irrigation, 6-12 hours, control 5/15/96, 6-12 hours |
| #3 | 6/24/96, one sample from rainfall, 6/24/96, irrigated plot only |
| #4 | 8/13/96, pre plant seed corn |
| #5 | 8/21-26/96, post-irrigation (5 days) |
| #6 | 1/97, pre plant irrigation, BMP plot 36-60 hours, post irrigation. control, 60-80 hour post irrigation |
| #7 | 6/14-15/97, post irrigation samples, cotton |

Key:

yes - BMP treated site shows clear reduction in concentration

no - BMP treated site shows no reduction in concentration

- - - Data is inconclusive

X - No data

Table 5. Dryland Demonstration Site: BMP Effectiveness in Reducing Concentrations in surface water runoff.

| Substance | Event | | | |
|---|---|---|---|---|
| | #1 | #2 | #3 | #4 |
| Ammonia Nitrogen | -- | no | no | -- |
| Nitrate Nitrogen | yes | X | no | -- |
| Nitrite Nitrogen | -- | X | no | -- |
| Total Kjeldahl Nitrogen | yes | no | no | -- |
| Orthophosphate Phosphorus | no | X | no | -- |
| Total Suspended Solids | yes | no | no | -- |
| Total Phosphorus | -- | no | no | -- |
| Chemical Oxygen Demand | yes | no | no | -- |
| Atrazine | -- | yes | -- | -- |
| Azinphos | -- | -- | -- | -- |
| Malathion | yes | no | -- | -- |
| Parathion | -- | -- | -- | -- |
| Permethrin | -- | -- | -- | -- |
| Prometryn | -- | -- | -- | -- |
| Trifluralin | -- | -- | -- | -- |

Footnotes:
Dryland Sampling Events

| Event | Description |
|---|---|
| #1 | 8/31/96, sorghum residue, rain event |
| #2 | 9/27-28/96, sorghum residue, rain event |
| #3 | 10/4-5/96, sorghum residue, large rain event |
| #4 | 3/11/97, sorghum residue, rain event |

Key:
yes - BMP treated site shows clear reduction in concentration
no - BMP treated site shows no reduction in concentration
- - - Data is inconclusive
X - No data

## Arroyo Colorado Water Quality Data Base

The Arroyo Colorado Water Quality Data Base was completed in December 1995 and submitted to the TSSWCB on diskette. We also analyzed the data base in order to determine its usefulness in assessing the water quality status and trends of the Arroyo Colorado. A progress report on this analysis was provided to the TSSWCB in August 1996, along with an updated diskette copy of the data base.

During 1996-1997, we continued our assessment of the data base and created the ***Arroyo Colorado Water Quality Data Base Web Site*** **(http://arroyo.tamu.edu)**. The Web Site contains all the water quality data assembled and a search engine, so that any user can perform his own search and analysis of the data base. The Web Site also provides details on the substances analyzed for and maps showing the locations of all monitoring stations.

The Report on the Web Site summarizes our evaluation of both the routine substances and the toxic substances data bases. A copy of the main screens and the text of the Report is provided in Appendix C of this report. The colored maps and charts, however, are not provided here, but are on the Web Site under Charts and Maps at *http://arroyo.tamu.edu*.

## Education and Technology Transfer Program

### Seminars and Workshops

We conducted a total of ten educational events as part of the educational program for the project. One workshop and seminar conducted each year was used for reporting purposes and to meet the contractual obligations. The other events were co-sponsored by the project in order to provide additional education opportunities for growers to learn about water quality problems and solutions. The TAEX project team planned, conducted, and spoke at these events. Table 6 lists the name of the event, date and estimated attendance.

### Fact Sheets

Four new fact sheets and one 2-page handout were written and published for the project. A short description of each follows with copies included in Appendix D of the report. On the back cover of each publication is a description of the Arroyo Colorado, documented water quality concerns, and the project.

Table 6. Educational Programs conducted as part of the Arroyo Colorado Project.

| Event | Date | Attendance |
| --- | --- | --- |
| Cotton Pre-Plant Clinic | 1/13/95 | 129 |
| Conservation Tillage in South Texas | 10/11/95 | 65 |
| Cotton Production and Physiology Workshop | 10/25/95 | 95 |
| Lower Rio Grande Irrigation Conference | 12/12/95 | 180 |
| Sprayer Calibration Clinic | 1/17/96 | 80 |
| Lower Rio Grande Irrigation Conference | 10/29/96 | 238 |
| Irrigation Field Day Tour | 10/30/96 | 120 |
| Cotton Pre-Plant Clinic | 1/15/97 | 85 |
| No-Till Filed Day | 4/30/97 | 250 |
| Seminar on the Arroyo Colorado | 8/28/97 | 45 |

***Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley*** by Alton Sparks and John Norman (500 copies, 8/97, 16 pages, 35 color photographs). Provides information on the appearance, basic biology and management of major pests of cotton and on occasional pests and beneficial organisms in the Lower Rio Grande Valley.

***Soil Fertility and Fertilizer Management*** by Mark McFarlland and Guy Fipps (1000 copies, 8/97, 10 pages, 3 photographs, 2 tables). Provides a complete guide to fertilizer management, soil fertility, soil testing and interpretation, and nutrient requirements of major crops.

***Irrigated Grain Sorghum Production*** by Charles Stickler and Guy Fipps (1000 copies, 8/97, 18 pages, 13 tables, 1 photograph). Provides a complete guide to grain sorghum production including proper nutrient, chemical and irrigation water management.

***Calibrating Pesticide Application Ground Equipment - Calibration Guide and Software*** by Bryan Show and Guy Fipps (500 copies, 10/96, 10 papes, 9 tables, 4 figures, software on CD). This publication and software provides a checklist and a complete guide to proper calibration of ground equipment used for applying pesticides and fertilizers.

***Help Yourself, Help the Environment*** (400 copies, 4/97, 2 pages, 1 photograph, 1 map). Two-page handout that links conservation tillage to water quality and summarizes this project.

A professional paper on the project, water quality issues, and the data base was presented at the ***Texas Water '95 Conference***, San Antonio, August 16-17, 1995 (American Society of Civil Engineers): *Is the Arroyo Colorado Polluted* by Guy Fipps and David Smith.

Video

The documentary video on the Arroyo Colorado Project is approximately 17 minutes long and provides an overview of the water quality status of the Arroyo, description of the project and BMPs implemented, and a discussion of additional BMPs appropriated for the area. TAEX contracted with Rick Steward Productions of Harlingen for filming, editing and production services. Rod Santa Ana oversaw filming and production. The script was written by Rod Santa Ana, David Smith and Guy Fipps. A copy of the video accompanies this report.

**Technical Assistance to TIAER in BMP Modeling**

Our assistance to TIAER consisted of the following:

1. instruction on the use of DRAINMOD;
2. design of the overall modeling strategy;
3. chemical, nutrient, and water usage under the normal year, dry year and wet year scenarios;
4. instruction on some of the limitations and interpretations of simulation results using EPIC, and
5. response to specific information requests, providing referrals as appropriate, and participation in brainstorming sessions.

The following TAEX personnel provided data to TIAER for the modeling effort: Terry Lockamy, Guy Fipps, Charles Stichler, John Norman, Julian Sauls, David Smith, Alton Sparks, and Ed Wilson.

# Appendix A: Arroyo Colorado Project Meeting Report

# ARROYO COLORADO PROJECT MEETING
Holiday Inn Sunspree,
South Padre Island, Texas
August 29-30, 1995

The meeting was called to order at 1:00 pm by Dr. Guy Fipps. Arrangements were made for the tour of the Arroyo Colorado to be held on August 30, 1995. Brad Cowan and Terry Lockamy will be responsible for the tour.

Introduction of the participants followed. The participants were as follows:

Dr. Guy Fipps, Extension Agricultural Engineer
Tony Gonzales, NRCS
Dr. John Bremer, Extension Weed Specialist
Luis Saldana, Willacy County Extension Agent
Doyle Warren, District 12 Extension Director
Terry Lockamy, Cameron County Extension Agent
Dr. Stormy Sparks, Extension Entomologist
Brad Cowan, Hidalgo County Extension Agent
Enrique Perez, Starr County Extension Agent
Dr. Bruce Lesikar, Extension Agricultural Engineer
Monty Dozier, Extension Associate
Dr. Bryan Shaw, Extension Agricultural Engineer
Dr. Steve Livingston, Extension Agronomist
Dr. Merrit Taylor, Extension Economist
Brent Bachelor, Atascosa County Extension Agent
Rod Santa Ana, Extension Communications Specialist
David Smith, Extension Assistant
Ed Wilson, Extension Graduate Assistant
Alan Moore, NRCS

The meeting continued with an overview of the Arroyo Colorado Project from it's beginning to the current status. The Texas State Soil and Water Conservation Board (TSSWCB) is responsible for overall project management. The Tarleton Institute for Applied Environmental Research (TIAER) will analyze the samples and conduct the computer modeling. The Texas Agricultural Extension Service will assist with Best Management Practice (BMP) selection and educational programs. The Natural Resource Conservation Service (NRCS) will assist with site identification and instrumentation, implementation of the BMP's (best management practices) and education of local farmers also interested in the BMP's.

The responsibilities of the project team are to:

a) Provide recommendations on BMP's for the demonstration sites;
b) Conduct an annual workshop;
c) Conduct an annual seminar;
d) distribute fact sheet(s);
e) evaluate monitoring data; and
f) produce a documentary video on the demonstrations and project;

An overview of water quality data for the Arroyo Colorado was presented by David Smith. Ed Wilson discussed our current assessment of the data base.

**BMP Selection**

The BMP will be implemented on an irrigated and two dryland sites (one a control). The irrigated field was previously instrumented and some information has been collected. However, the Quality Assurance Project Plan (QAPP) has not received approval from the TNRCC and USEPA at this point, and no monitoring or sampling can begin.

Irrigated Site

The irrigated field is leveled and has subsurface drainage perpendicular to the row direction.

Existing BMP's:

a) Subsurface drainage to control salinity and waterlogging from canal seepage
b) Land leveling

No other information has been provided, and these are the only BMP's known by NRCS.

Possible BMP's include but not limited to:

a) integrated pest management;
b) residue management;
c) field scouting for herbicide applications;
d) fertilizer rates based on pre-plant soil analysis;
e) split fertilizer applications;
f) proper irrigation water management:
    - irrigation scheduling by soil moisture status and current ET,
    - use of gated pipe, and
    - use of surge flow irrigation if poor distribution uniformity exists;
g) proper calibration and operation of sprayer equipment;

h) reduced tillage.

Dryland Site:

The dryland farm is a sixty acre field which will be divided into two fields. One field will be the control and the other field will have the BMP's implemented. The BMP field will be leveled with no slope across the rows and a slope of one-third of a tenth per one hundred feet with the row.

Planned BMP (known):

land leveling

Possible BMP's include but are not limited to:

a) integrated pest management;
b) residue management;
c) field scouting for herbicide applications;
d) fertilizer rates based on pre-plant soil analysis;
e) split fertilizer applications;
g) proper calibration and operation of sprayer equipment;
h) reduced tillage.

The effectiveness of the BMP's will be measured with respect to specific parameters. Water Quality Standards should be established to set a target for the water quality to be attained.

**Monitoring**

Irrigated Site (Current):

a) subsurface drainage water sampling;
b) rainfall.

Possible (depending on which BMP's are implemented and evaluated):

a) irrigation volumes (measured, not estimated) and timing;
b) irrigation water sampling;
c) runoff volumes and quality;
d) drainwater volumes and hydrographs;
e) soil sampling:
    - nutrients for fertilizer recommendations,
    - deep soil sampling for nutrient movement,
    - hydrologic properties for modeling.

f) evapotranspiration;
g) pest scouting and counts;
h) document weed presence;
I) yield and quality of crop;
j) soil moisture;
j) expense records/costs of production;
k) a control for the irrigated site;
h) shallow water table depth and quality.

Dryland Site (known):

Surface water runoff / Quality and Quantity

Needs:

Sediment in Runoff

Possible (depending on which BMP's are implemented and evaluated):

a) soil sampling:
   - nutrients for fertilizer recommendations,
   - deep soil sampling for nutrient movement,
   - hydrologic properties for modeling;
b) evapotranspiration;
c) pest scouting and counts;
d) document weed presence;
e) yield and quality of crop;
f) soil moisture;
g) expense records/costs of production;

**Fact Sheet**

The TAEX will develop a fact sheet to be distributed to the local community on pesticide/fertilizer. The group conducted a brainstorming session to determine ideas for possible fact sheets.

Ideas

Series on Nonpoint Source Pollution from the TSSWCB be rewritten
Crop Production Handbook Information
Citrus Production Handbook Information
Sprayer Calibration Fact Sheet
Potential Sources of Nonpoint Source Pollutants and How to Control Them

Physical Aspect of the Lower Rio Grande Valley which shows the potential source of pollutants and the drainage area which goes into the Arroyo Colorado (Background Information on the Arroyo Colorado to assist producers understand that they are part of the Arroyo Colorado Watershed and how they may be impacting the water quality in the Arroyo). Corp of Engineers may have a GIS map that describes the Arroyo Colorado Watershed.
Current Status of the Arroyo Colorado Water Quality
Existing information Sheet(s)
Sugarcane publication

**Video**

A video will be developed to describe the installation of the demonstration projects. Rod Santa Ana will serve as the coordinator of the video program. Additional people on the video committee will be Luis Saldana, Doyle Warren, Terry Lockamy, Stormy Sparks, and Brad Cowan. Bruce Lesikar and Guy Fipps will be advisors. The entire project team will review the video script. A list of items to be included in the video was described as follows:

Aerial view of the demonstration sites and the Arroyo Colorado along with:
- potential sources of nonpoint source pollution
- Crop fields
- Urban Landscape

Land leveling of the site
Finished demonstration sites

**Workshops**

1. A residue management workshop will be held on Oct. 11 in Willacy County.
2. A sprayer calibration workshop can be conducted on December 14, 1995 in Mercedes.

**Seminar**

Opportunities:

1) Cotton Production Meeting, October 25, 1995, also have a component on Nonpoint Source Pollution
2) Irrigation Conference, Jan-Feb, 1996 also have a component on Nonpoint Source Pollution

The irrigation conference will have a program committee consisting of chairman Guy Fipps, members include Merrit Taylor, Stormy Sparks, Bruce Lesikar. The conference will focus on agricultural producers but will also have a component for the Urban irrigators.

**Budget**

The current budget was presented and the project team informed that Extension will receive an additional funds, pending revised work plan acceptance.

**Forward Planning**

Video due in December, 1996

Another Planning meeting to be held next fall to evaluate the data collected from the demonstration project.

# *Appendix B: Arroyo Colorado Monitoring Data*

# Arroyo Colorado Monitoring Data

## Variable - *format:*

Site - *alpha numeric site designation (see abbreviations) 5.*
Sample # - *numeric 10.0*
Date - *mm/dd/yy*
Time - *hh:mm [military, central standard time]*
NH3-N value - *numeric 8.4*
NH3-N remark - *alpha numeric*
NO2-N value - *numeric 6.3*
NO2-N remark - *alpha numeric*
NO3-N value - *numeric 7.3*
NO3-N remark - *alpha numeric*
TKN value - *numeric 6.2*
TKN remark - *alpha numeric*
PO4-P value - *numeric 6.3*
PO4-P remark - *alpha numeric*
TP value - *numeric 7.3*
TP remark - *alpha numeric*
TSS value - *numeric 8.2*
TSS remark - *alpha numeric*
COD value - *numeric 6.1*
COD remark - *alpha numeric*
Atrazine value - *numeric 8.3*
Atrazine remark - *alpha numeric*
Azinphos (methyl) value - *numeric 8.3*
Azinphos (methyl) remark - *alpha numeric*
Malathion value - *numeric 8.3*
Malathion remark - *alpha numeric*
Parathion (methyl) value - *numeric 8.3*
Parathion (methyl) remark - *alpha numeric*
Permethrin (cis/trans) value - *numeric 8.3*
Permethrin (cis/trans) remark - *alpha numeric*
Prometryn value - *numeric 8.3*
Prometryn remark - *alpha numeric*
Trifluralin value - *numeric 8.3*
Trifluralin remark - *alpha numeric*
Comments - *alpha numeric field containing general comments relating to the sample*

NOTE: For each constituent, a value field and a remark field is listed. The value field contains numeric concentration values. Missing data is denoted with a period (.). The remark field contains explanatory notes relating to the data point such as the method detection limit. When the analyte concentration was below the method detection limit (MDL) for the analytical procedure, the MDL is denoted in the remark column. One-half (1/2) the MDL was reported for concentration values for the following constituents: NH3-N, NO2-N, NO3-N, TKN, PO4-P, TP, TSS, COD. When pesticide concentrations were below the MDL, concentration values were reported as zero (0). If no concentration value is reported, the remark field usually contains an explanation for the missing data. If a quality assurance test fails for a group of samples, no value is assigned to the sample for the affected parameters. A period is entered into the value field and "est. < MDL" is entered into the remark field. When a reduced sample volume was used for a test, the associated MDL was doubled.

## Abbreviations and Reporting Units:

| Constituent | Abbreviation | Units Reported |
|---|---|---|
| Ammonia Nitrogen | NH3-N | mg/L |
| Nitrite Nitrogen | NO2-N | mg/L |
| Nitrate Nitrogen | NO3-N | mg/L |
| Total Kjeldahl Nitrogen | TKN | mg/L |
| Orthophosphate Phosphorus | PO4-P | mg/L |
| Total Phosphorus | TP | mg/L |
| Total Suspended Solids | TSS | mg/L |
| Chemical Oxygen Demand | COD | mg/L |
| Atrazine | ATRAZ | µg/L |
| Azinphos (methyl) | AZINP | µg/L |
| Malathion | MALAT | µg/L |
| Parathion (methyl) | PARAT | µg/L |
| Permethrin (cis/trans) | PERME | µg/L |
| Prometryn | PROME | µg/L |
| Trifluralin | TRIFL | µg/L |

Abbreviations
bmpdr = Dryland Site with BMP
condr = Dryland Site (Control, without BMP)
bmpir = Irrigated Site with BMP
conir = Irrigated Site (Control, without BMP)
HTEF = Holding time exceeded (field)
EST = Estimated value and/or quality control test(s) fail
IM = Instrument Malfunction
mg/L = milligram per liter
µg/L = microgram per liter
STAT = statistically close
ND = no detection, i.e., concentration is below method detection limit

C97-### or car97### - indicates the reference number (###) of the corrective action report submitted for the sample

## Inquiries:

If you have any questions regarding the data reported, please direct inquiries to one of the following individuals.


| | | | |
|---|---|---|---|
| Joan Flowers | (254) 968-9554 | flowers@tiaer.tarleton.edu | Project Manager |
| Nancy Easterling | (254) 968-9548 | easterl@tiaer.tarleton.edu | Quality Assurance Officer |
| Larry Hauck | (254) 968-9561 | hauck@tiaer.tarleton.edu | Project Administrator |


These data are also available in digital format by directing a written request to:


Texas Institute for Applied Environmental Research
Tarleton State University
Box T0410, Tarleton Station
Stephenville, Texas 76402
Attention: Joan Flowers
email: flowers@tiaer.tarleton.edu

Results of Water Quality Mon[illegible]g - Arroyo Colorado Project

Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value mg/L | NH3-N remark | NO2-N value mg/L | NO2-N remark | NO3-N value mg/L | NO3-N remark | TKN value mg/L | TKN remark | PO4-P value mg/L | PO4-P remark | TP value mg/L | TP remark | TSS value mg/L | TSS remark | COD value mg/L | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0.09 | | 0.001 | <.002 | 0.42 | | 16.5 | | 0.36 | | 8.82 | | 8120 | | 204 | |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 0.1 | | 0.001 | <.002 | 0.11 | | 0.72 | | 0.39 | | 0.68 | | 162 | | 22 | |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0.12 | | 0.001 | <.002 | 0.1 | | 0.91 | | 0.38 | | 0.64 | | 86 | | 18 | |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 0.11 | | 0.001 | <.002 | 0.1 | | 0.9 | | 0.37 | | 0.64 | | 68 | | 22 | |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0.14 | | 0.001 | <.002 | 0.11 | | 0.9 | | 0.38 | | 0.69 | | 66 | | 16 | |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0.14 | | 0.001 | <.002 | 0.09 | | 0.93 | | 0.38 | | 0.74 | | 100 | | 8 | |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0.28 | | . | HTEF | . | HTEF | 15.8 | | . | HTEF | 8.12 | | 6260 | | 124 | |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0.15 | | . | HTEF | . | HTEF | 3.95 | | . | HTEF | 2.75 | | 1590 | | 42 | |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | 0.14 | | 0.008 | | 0.12 | | 8.71 | | 0.45 | | 4.44 | | 2500 | | 132 | |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | 0.15 | | 0.004 | | 0.06 | | 4.71 | | 0.42 | | 3.01 | | 1920 | | 68 | |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0.16 | | 0.005 | | 0.05 | | 2.26 | | 0.37 | | 1.6 | | 719 | | 26 | |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0.16 | | 0.006 | | 0.08 | | 4.58 | | 0.36 | | 2.81 | | 1950 | | 66 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 0.13 | | 0.004 | | 0.06 | | 1.9 | | 0.3 | | 1.28 | | 781 | | 21 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0.13 | | 0.003 | | 0.03 | | 1.77 | | 0.21 | | 0.96 | | 574 | | 15 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0.09 | | 0.001 | <.002 | 0.008 | <.015 | 0.91 | | 0.25 | | 0.57 | | 587 | | 6 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 0.53 | | 0.01 | | 0.08 | | 4.53 | | 0.52 | | 2.06 | | 1260 | | 11 | |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 0.08 | | 0.014 | | 0.08 | | 1.96 | | 0.27 | | 1.19 | | 726 | | 9 | |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 0.08 | | 0.011 | | 0.08 | | 1.21 | | 0.35 | | 0.75 | | 210 | | 8 | |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0.03 | | 0.005 | | 16.6 | | 0.7 | | 0.08 | | 0.055 | <.11 | 21 | | 36 | |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0.03 | | 0.005 | | 15.7 | | 0.84 | | 0.11 | | 0.055 | <.11 | 39 | | 23 | |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0.0075 | <.015 | 0.02 | | 13.2 | | 0.75 | | 0.08 | | 0.055 | <.11 | 18.7 | | 24 | |
| bmpir | 1000018439 | 5/14/96 | 6:00 | 0.11 | | 0.04 | | 11.6 | | 0.78 | | 0.06 | | 0.19 | | 17 | | 19 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | 0.31 | | 0.05 | | 12 | | 0.85 | | 0.06 | | 0.15 | | 5 | <10 | 15 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | 0.09 | | 0.02 | | 11.4 | | 1.02 | | 0.06 | | 0.14 | | 25 | | 18 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | 0.0075 | <.015 | 0.05 | | 12.9 | | 0.81 | | 0.06 | | 1.21 | | 26 | | 19 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | 0.06 | | 0.05 | | 13 | | 1.09 | | 0.07 | | 0.17 | | 32 | | 21 | |
| bmpir | 1000018444 | 5/15/96 | 6:00 | 0.0075 | <.015 | 0.03 | | 12.8 | | 0.84 | | 0.07 | | 0.055 | <.11 | 14 | | 18 | |
| bmpir | 1000018445 | 5/15/96 | 12:00 | 0.0075 | <.015 | 0.02 | | 13.8 | | 0.98 | | 0.08 | | 0.11 | | 17 | | 20 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | 0.0075 | <.015 | 0.018 | | 13.5 | | 0.51 | | 0.07 | | 0.16 | | 12 | | 22 | |
| bmpir | 1000018452 | 5/16/96 | 0:00 | 0.0075 | <.015 | 0.004 | | 13.2 | | 0.46 | | 0.07 | | 0.14 | | 12 | | 20 | |
| bmpir | 1000018453 | 5/16/96 | 6:00 | 0.0075 | <.015 | 0.004 | | 13.2 | | 0.55 | | 0.07 | | 0.055 | <.11 | 84 | | 18 | |
| bmpir | 1000018454 | 5/16/96 | 12:00 | 0.0075 | <.015 | 0.009 | | 12.7 | | 0.7 | | 0.06 | | 0.055 | <.11 | 11 | | 16 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.46 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 19 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | 0.05 | | . | HTEF | . | HTEF | 0.53 | | . | HTEF | 0.055 | <.11 | 11 | | 26 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | 0.06 | | . | HTEF | . | HTEF | 0.36 | | . | HTEF | 0.055 | <.11 | 20 | | 16 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.7 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 16 | |

Results of Water Quality Monito[illegible] - Arroyo Colorado Project

Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.47 | | . | HTEF | 0.055 | <.11 | 10 | | 21 | |
| bmpir | 1000018460 | 5/18/96 | 0:00 | 0.0075 | <.015 | 0.003 | | 11.4 | | 0.67 | | 0.07 | | 0.11 | | 12 | | 21 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | 0.0075 | <.015 | 0.006 | | 11.5 | | 0.54 | | 0.07 | | 0.055 | <.11 | 19 | | 21 | |
| bmpir | 1000019617 | 6/24/96 | 17:00 | 1.03 | | 0.001 | <.002 | 0.3 | | 2.18 | | 0.07 | | 0.24 | | 43 | | 12 | |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 0.12 | | . | HTEF | . | HTEF | 0.99 | | . | HTEF | 0.33 | | 52 | | 32 | |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 0.1 | | . | HTEF | . | HTEF | 1.08 | | . | HTEF | 0.22 | | 19 | | 24 | |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 0.12 | | 0.014 | | 2.69 | | 1.07 | | 0.05 | | 0.2 | | 53 | | 23 | |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 0.12 | | 0.01 | | 2.47 | | 1.15 | | 0.05 | | 0.21 | | 11 | | 17 | |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 0.16 | | 0.08 | | 3.21 | | 1.28 | | 0.04 | | 0.2 | | 35 | | 21 | |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 0.11 | | 0.04 | | 3.26 | | 1.09 | | 0.05 | | 0.23 | | 18 | | 20 | |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 0.11 | | . | HTEF | . | HTEF | 0.91 | | . | HTEF | 0.16 | | 19 | | 15 | |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0.11 | | 0.001 | <.002 | 4.36 | | 0.77 | | 0.09 | | 0.14 | | 10 | | 15 | |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0.12 | | 0.001 | <.002 | 4.58 | | 0.86 | | 0.09 | | 0.13 | | 5 | <10 | 15 | |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0.13 | | . | HTEF | . | HTEF | 0.78 | | . | HTEF | 0.13 | | 26 | | 11 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0.07 | | . | HTEF | . | HTEF | 0.53 | | . | HTEF | 0.16 | | 14 | | 17 | |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0.06 | | . | HTEF | . | HTEF | 0.79 | | . | HTEF | 0.13 | | 10 | | 13 | |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0.07 | | 0.08 | | 0.008 | <.015 | 0.89 | | 4.17 | | 0.055 | <.11 | 14 | | 13 | |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 0.08 | | 0.04 | | 4.56 | | 0.69 | | 0.08 | | 0.13 | | 16 | | 15 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 0.05 | | 0.03 | | 4.71 | | 0.69 | | 0.08 | | 0.12 | | 18 | | 19 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | 0.14 | | 0.017 | | 4.72 | | 0.74 | | 0.08 | | 0.11 | | 11 | | 18 | |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 0.06 | | 0.001 | <.002 | 4.54 | | 0.67 | | 0.09 | | 0.055 | <.11 | 12 | | 20 | |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 0.11 | | 0.001 | <.002 | 4.47 | | 0.86 | | 0.08 | | 0.24 | | 24 | | 9 | |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 0.09 | | 0.001 | <.002 | 4.55 | | 0.76 | | 0.09 | | 0.19 | | 14 | | 10 | |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 0.1 | | 0.002 | | 4.32 | | 0.73 | | 0.09 | | 0.18 | | 28 | | 9 | |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 0.0075 | <.015 | 0.004 | | 4.41 | | 0.94 | | 0.08 | | 0.055 | <.11 | 24 | | 13 | |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 0.0075 | <.015 | 0.004 | | 4.48 | | 0.66 | | 0.08 | | 0.055 | <.11 | 21 | | 17 | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 0.05 | | 0.003 | | 4.49 | | 0.68 | | 0.08 | | 0.055 | <.11 | 15 | | 14 | |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 0.16 | | 0.012 | | 3.98 | | 1.07 | | 0.08 | | 0.055 | <.11 | 27 | | 13 | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 0.1 | | 0.001 | <.002 | 5.98 | | 1.32 | | 0.07 | | 0.26 | | 29 | | 22 | |
| bmpir | 1000021090 | 8/26/96 | 22:00 | . | EST .72 | 0.001 | <.002 | 5.75 | | 0.96 | | 0.08 | | 0.21 | | 16 | | 20 | |
| bmpir | 1000021091 | 8/27/96 | 2:00 | . | EST .56 | 0.001 | <.002 | 5.69 | | 0.81 | | 0.09 | | 0.17 | | 11 | | 24 | |
| bmpir | 1000021092 | 8/27/96 | 6:00 | . | EST .64 | 0.001 | <.002 | 5.57 | | 0.94 | | 0.08 | | 0.17 | | 16 | | 22 | |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0.47 | | 0.001 | <.002 | 5.82 | | 0.96 | | 0.08 | | 0.12 | | 16 | | 15 | |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0.61 | | 0.001 | <.002 | 5.43 | | 0.9 | | 0.17 | | 0.055 | <.11 | 12 | | 17 | |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 0.12 | | 0.001 | <.002 | 6.22 | | 0.63 | | 0.07 | | 0.17 | | 11 | | 20 | |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 0.3 | | 0.001 | <.002 | 6.32 | | 0.67 | | 0.08 | | 0.18 | | 15 | | 21 | |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 0.17 | | 0.001 | <.002 | 5.86 | | 0.65 | | 0.07 | | 0.13 | | 5 | <10 | 21 | |

Results of Water Quality Mot. - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0.16 | | 0.001 | <.002 | 5.97 | | 0.75 | | 0.07 | | 0.12 | | 5 | <10 | 21 | |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0.12 | | 0.001 | <.002 | 5.6 | | 0.88 | | 0.08 | | 0.12 | | 5 | <10 | 21 | |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0.45 | | 0.001 | <.002 | 5.64 | | 0.88 | | 0.08 | | 0.2 | | 5 | <10 | 22 | |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0.07 | | 0.011 | | 4.61 | | 0.57 | | 0.08 | | 0.12 | | 25 | | 25 | |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0.09 | | 0.011 | | 5.05 | | 0.7 | | 0.08 | | 0.13 | | 14 | | 23 | |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0.09 | | 0.008 | | 4.89 | | 0.77 | | 0.08 | | 0.055 | <.11 | 15 | | 22 | |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0.08 | | 0.011 | | 5.08 | | 0.43 | | 0.08 | | 0.055 | <.11 | 16 | | 22 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0.08 | | 0.018 | | 5.15 | | 0.43 | | 0.08 | | 0.26 | | 5 | <10 | 19 | |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0.14 | | 0.011 | | 5.29 | | 0.44 | | 0.09 | | 0.28 | | 11 | | 18 | |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 0.03 | | . | HTEF | . | HTEF | 1 | | . | HTEF | 0.28 | | 19 | | 17 | |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 0.03 | | . | HTEF | . | HTEF | 0.99 | | . | HTEF | 0.18 | | 16 | | 17 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0.04 | | . | HTEF | . | HTEF | 0.77 | | . | HTEF | 0.15 | | 5 | <10 | 16 | |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0.05 | | . | HTEF | . | HTEF | 0.73 | | . | HTEF | 0.13 | | 26 | | 13 | |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0.1 | | 0.04 | | 4.27 | | 0.71 | | 0.07 | | 0.14 | | 32 | | 17 | |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 0.08 | | 0.04 | | 4.78 | | 0.87 | | 0.09 | | 0.051 | <.101 | 12 | | 12 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 0.11 | | 0.04 | | 5.1 | | 0.79 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 11 | |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 0.1 | | 0.04 | | 5.52 | | 0.62 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 10 | |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 0.15 | | 0.03 | | 5.12 | | 0.53 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 9 | |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 0.09 | | 0.03 | | 4.62 | | 0.73 | | 0.09 | | 0.051 | <.101 | 5 | <10 | 7 | |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 0.06 | | 0.05 | | 5.89 | | 1.2 | | 0.07 | | 0.19 | | 5 | <10 | 17 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 0.07 | | 0.06 | | 5.95 | | 1.22 | | 0.09 | | 0.14 | | 10 | | 19 | |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0.06 | | 0.05 | | 6.22 | | 1.31 | | 0.08 | | 0.13 | | 5 | <10 | 20 | |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0.05 | | 0.05 | | 6 | | 1.25 | | 0.08 | | 0.15 | | 5 | <10 | 16 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0.0185 | <.037 | 0.05 | | 5.9 | | 0.69 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 12 | |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0.06 | | 0.05 | | 5.93 | | 0.72 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 1.08 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 15 | |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 1.57 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 0.89 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 0.04 | | . | HTEF | . | HTEF | 0.82 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 0.04 | | . | HTEF | . | HTEF | 0.86 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 19 | |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 0.05 | | 0.05 | | 6.03 | | 0.87 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 0.04 | | 0.05 | | 6.08 | | 0.81 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026469 | 2/4/97 | 0:00 | 0.0185 | <.037 | 0.05 | | 6.05 | | 0.78 | | 0.16 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 0.04 | | 0.05 | | 5.84 | | 0.84 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 0.05 | | 0.05 | | 5.8 | | 0.66 | | 0.14 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0.07 | | . | car97201 | . | car97201 | 1.17 | | . | car97201 | 0.039 | <.077 | 22 | | 11 | |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0.05 | | . | car97201 | . | car97201 | 1.08 | | . | car97201 | 0.1 | STAT | 14 | | 2 | <4 |

Results of Water Quality Monito[illegible] - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0.07 | | . | car97201 | . | car97201 | 1.21 | | . | car97201 | 0.08 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0.09 | | . | car97201 | . | car97201 | 0.76 | | . | car97201 | 0.34 | | . | C97-203 | 2 | <4 |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0.14 | | . | car97201 | . | car97201 | 0.77 | | . | car97201 | 0.28 | | . | C97-203 | 2 | <4 |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0.05 | | . | car97201 | . | car97201 | 0.67 | | . | car97201 | 0.26 | | 5 | <10 | 9 | |
| bmpir | 1000032693 | 6/14/97 | 22:00 | 0.07 | | 0.011 | | 6.04 | | 0.59 | | 0.11 | | 0.16 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032694 | 6/15/97 | 2:00 | 0.04 | | 0.006 | | 5.88 | | 0.57 | | 0.13 | | 0.15 | | 16 | | 5 | |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 0.05 | | 0.007 | | 6.01 | | 0.69 | | 0.11 | | 0.14 | | 5 | <10 | 4 | |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 0.08 | | 0.014 | | 4.9 | | 0.76 | | 0.1 | | 0.29 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 0.18 | | 0.01 | | 5.31 | | 0.88 | | 0.11 | | 0.45 | | 5 | <10 | 9 | |
| condr | 1000021630 | 8/31/96 | 16:00 | 0.11 | | 0.001 | <.002 | 0.77 | | 25.2 | | 0.39 | | 10.5 | | 11700 | | 380 | |
| condr | 1000023112 | 9/27/96 | 23:00 | 0.31 | | . | HTEF | . | HTEF | 17.2 | | . | HTEF | 5.48 | | 5760 | | 117 | |
| condr | 1000023113 | 9/28/96 | 1:00 | 0.15 | | . | HTEF | . | HTEF | 4.9 | | . | HTEF | 2.48 | | 1660 | | 53 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 0.64 | | 0.006 | | 0.11 | | 7.6 | | 0.37 | | 3.83 | | 3050 | | 108 | |
| condr | 1000023175 | 10/5/96 | 2:00 | 0.2 | | 0.006 | | 0.1 | | 4.45 | | 0.37 | | 2.5 | | 1760 | | 55 | |
| condr | 1000023176 | 10/5/96 | 4:00 | 0.16 | | 0.005 | | 0.06 | | 3.67 | | 0.45 | | 2.22 | | 1600 | | 54 | |
| condr | 1000023177 | 10/5/96 | 6:00 | 0.16 | | 0.004 | | 0.06 | | 1.81 | | 0.39 | | 1.25 | | 471 | | 16 | |
| condr | 1000023178 | 10/5/96 | 8:00 | 0.15 | | 0.004 | | 0.06 | | 1.89 | | 0.35 | | 1.02 | | 593 | | 8 | |
| condr | 1000023179 | 10/5/96 | 10:00 | 0.13 | | 0.001 | <.002 | 0.05 | | 1.46 | | 0.27 | | 0.98 | | 626 | | 20 | |
| condr | 1000023189 | 10/5/96 | 20:00 | 0.13 | | 0.001 | <.002 | 0.018 | | 0.47 | | 0.21 | | 0.29 | | 70 | | 2.5 | <5 |
| condr | 1000023190 | 10/6/96 | 0:00 | 0.09 | | 0.001 | <.002 | 0.02 | | 0.59 | | 0.23 | | 0.35 | | 110 | | 2.5 | <5 |
| condr | 1000023191 | 10/6/96 | 4:00 | 0.09 | | 0.001 | <.002 | 0.016 | | 0.51 | | 0.23 | | 0.31 | | 35 | | 2.5 | <5 |
| condr | 1000029148 | 3/11/97 | 8:00 | 0.19 | | 0.02 | | 0.18 | | 3.77 | | 0.38 | | 2.08 | | 1540 | | 13 | |
| conir | 1000018214 | 4/16/96 | 4:00 | 0.04 | | 0.015 | | 15.7 | | 0.63 | | 0.07 | | 0.055 | <.11 | 74 | | 36 | |
| conir | 1000018213 | 4/16/96 | 16:00 | 0.06 | | 0.04 | | 16.4 | | 0.91 | | 0.07 | | 0.13 | | 197 | | 30 | |
| conir | 1000018215 | 4/17/96 | 4:00 | 0.17 | | 0.001 | <.002 | 16 | | 0.74 | | 0.08 | | 0.18 | | 176 | | 27 | |
| conir | 1000018455 | 5/16/96 | 0:00 | 0.0075 | <.015 | 0.003 | | 13.6 | | 0.84 | | 0.08 | | 0.2 | | 119 | | 20 | |
| conir | 1000018456 | 5/16/96 | 3:00 | 0.0075 | <.015 | 0.004 | | 13.4 | | 0.65 | | 0.07 | | 0.16 | | 60 | | 20 | |
| conir | 1000018457 | 5/16/96 | 6:00 | 0.0075 | <.015 | 0.002 | | 13.2 | | 0.98 | | 0.08 | | 0.11 | | 31 | | 20 | |
| conir | 1000018458 | 5/16/96 | 12:00 | 0.0075 | <.015 | 0.002 | | 12.6 | | 0.67 | | 0.08 | | 0.055 | <.11 | 40 | | 16 | |
| conir | 1000018469 | 5/16/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.42 | | . | HTEF | 0.14 | | 16 | | 16 | |
| conir | 1000018470 | 5/17/96 | 0:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.34 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 21 | |
| conir | 1000018471 | 5/17/96 | 6:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.63 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 22 | |
| conir | 1000018472 | 5/17/96 | 12:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.43 | | . | HTEF | 0.055 | <.11 | 10 | | 21 | |
| conir | 1000018462 | 5/17/96 | 18:00 | 0.04 | | . | HTEF | . | HTEF | 0.79 | | . | HTEF | 0.14 | | 27 | | 23 | |
| conir | 1000018463 | 5/18/96 | 0:00 | 0.02 | | 0.07 | | 12.5 | | 0.6 | | 0.09 | | 0.12 | | 14 | | 20 | |
| conir | 1000018464 | 5/18/96 | 12:00 | 0.0075 | <.015 | 0.003 | | 14.1 | | 0.46 | | 0.07 | | 0.055 | <.11 | 13 | | 20 | |
| conir | 1000018473 | 5/18/96 | 18:00 | 0.0075 | <.015 | 0.003 | | 11.7 | | 0.61 | | 0.07 | | 0.055 | <.11 | 14 | | 34 | |

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 2.81 | | 0.07 | | 1.35 | | 4.4 | | 0.06 | | 0.29 | | 81 | | 19 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 1.67 | | 0.09 | | 1.92 | | 3.11 | | 0.09 | | 0.2 | | 56 | | 12 | |
| conir | 1000020859 | 8/18/96 | 23:00 | 1.03 | | 0.019 | | 2.8 | | 2.05 | | 0.08 | | 0.17 | | 16 | | 13 | |
| conir | 1000020860 | 8/19/96 | 2:00 | 0.74 | | 0.014 | | 3.12 | | 1.68 | | 0.08 | | 0.17 | | 5 | <10 | 14 | |
| conir | 1000020861 | 8/19/96 | 8:00 | 0.32 | | 0.008 | | 3.58 | | 1.28 | | 0.07 | | 0.14 | | 5 | <10 | 10 | |
| conir | 1000020862 | 8/19/96 | 14:00 | 0.1 | | 0.003 | | 3.52 | | 0.88 | | 0.06 | | 0.22 | | 14 | | 11 | |
| conir | 1000020947 | 8/19/96 | 20:00 | 0.07 | | 0.006 | | 3.2 | | 0.85 | | 0.06 | | 0.055 | <.11 | 19 | | 10 | |
| conir | 1000020948 | 8/20/96 | 2:00 | 0.06 | | 0.006 | | 3.03 | | 0.93 | | 0.06 | | 0.14 | | 5 | <10 | 11 | |
| conir | 1000020949 | 8/20/96 | 8:00 | 0.37 | | 0.019 | | 2.66 | | 1.54 | | 0.06 | | 0.055 | <.11 | 14 | | 11 | |
| conir | 1000020950 | 8/20/96 | 14:00 | 0.06 | | 0.009 | | 2.85 | | 0.57 | | 0.06 | | 0.055 | <.11 | 12 | | 11 | |
| conir | 1000020966 | 8/20/96 | 20:00 | 0.04 | | 0.001 | <.002 | 2.78 | | 0.6 | | 0.07 | | 0.055 | <.11 | 5 | <10 | 16 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0.11 | | 0.001 | <.002 | 2.75 | | 0.59 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 14 | |
| conir | 1000020968 | 8/21/96 | 8:00 | 0.06 | | 0.001 | <.002 | 2.79 | | 0.91 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 18 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0.06 | | 0.001 | <.002 | 2.82 | | 0.92 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 12 | |
| conir | 1000021095 | 8/26/96 | 18:00 | 0.54 | | 0.001 | <.002 | 6.41 | | 1.13 | | 0.2 | | 0.18 | | 86 | | 11 | |
| conir | 1000021096 | 8/26/96 | 22:00 | 0.51 | | 0.001 | <.002 | 6.31 | | 1.01 | | 0.21 | | 0.19 | | 18 | | 20 | |
| conir | 1000021097 | 8/27/96 | 2:00 | 0.34 | | 0.001 | <.002 | 6.11 | | 0.9 | | 0.18 | | 0.27 | | 12 | | 18 | |
| conir | 1000021098 | 8/27/96 | 6:00 | 0.25 | | 0.001 | <.002 | 6.16 | | 0.98 | | 0.08 | | 0.24 | | 16 | | 20 | |
| conir | 1000021099 | 8/27/96 | 10:00 | 0.13 | | 0.001 | <.002 | 6 | | 0.76 | | 0.09 | | 0.2 | | 5 | <10 | 21 | |
| conir | 1000021100 | 8/27/96 | 14:00 | 0.27 | | 0.07 | | 5.5 | | 1 | | 0.09 | | 0.17 | | 11 | | 21 | |
| conir | 1000021141 | 8/27/96 | 18:00 | 0.17 | | 0.001 | <.002 | 5.28 | | 0.78 | | 0.08 | | 0.14 | | 11 | | 20 | |
| conir | 1000021142 | 8/27/96 | 22:00 | 0.17 | | 0.001 | <.002 | 5.19 | | 0.86 | | 0.08 | | 0.055 | <.11 | 5 | <10 | 22 | |
| conir | 1000021143 | 8/28/96 | 2:00 | 0.08 | | 0.001 | <.002 | 5.02 | | 0.63 | | 0.08 | | 0.055 | <.11 | 5 | <10 | 18 | |
| conir | 1000021144 | 8/28/96 | 6:00 | 0.14 | | 0.001 | <.002 | 5.33 | | 0.65 | | 0.08 | | 0.055 | <.11 | 36 | | 18 | |
| conir | 1000021145 | 8/28/96 | 10:00 | 0.1 | | 0.001 | <.002 | 5.13 | | 0.6 | | 0.08 | | 0.055 | <.11 | 16 | | 18 | |
| conir | 1000021146 | 8/28/96 | 14:00 | 0.0075 | <.015 | 0.001 | <.002 | 5.05 | | 0.71 | | 0.08 | | 0.055 | <.11 | 12 | | 23 | |
| conir | 1000021306 | 8/28/96 | 18:00 | 0.11 | | 0.014 | | 5.94 | | 0.59 | | 0.07 | | 0.27 | | 5 | <10 | 23 | |
| conir | 1000021307 | 8/28/96 | 22:00 | 0.14 | | 0.014 | | 5.79 | | 0.78 | | 0.07 | | 0.22 | | 24 | | 25 | |
| conir | 1000021308 | 8/29/96 | 2:00 | 0.12 | | 0.011 | | 5.45 | | 0.34 | | 0.08 | | 0.17 | | 5 | <10 | 22 | |
| conir | 1000021309 | 8/29/96 | 6:00 | 0.09 | | 0.008 | | 5.75 | | 0.9 | | 0.08 | | 0.15 | | 5 | <10 | 22 | |
| conir | 1000021310 | 8/29/96 | 10:00 | 0.12 | | 0.011 | | 5.89 | | 0.41 | | 0.08 | | 0.13 | | 5 | <10 | 20 | |
| conir | 1000021311 | 8/29/96 | 14:00 | 0.11 | | 0.011 | | 5.42 | | 0.47 | | 0.08 | | 0.13 | | 5 | <10 | 21 | |
| conir | 1000021637 | 8/29/96 | 20:00 | 0.03 | | . | HTEF | . | HTEF | 0.85 | | . | HTEF | 0.12 | | 5 | <10 | 15 | |
| conir | 1000021638 | 8/30/96 | 2:00 | 0.02 | | . | HTEF | . | HTEF | 1.03 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 17 | |
| conir | 1000021639 | 8/30/96 | 8:00 | 0.018 | | . | HTEF | . | HTEF | 0.85 | | . | HTEF | 0.15 | | 5 | <10 | 18 | |
| conir | 1000021640 | 8/30/96 | 14:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 1.14 | | . | HTEF | 0.15 | | 16 | | 16 | |
| conir | 1000026427 | 1/29/97 | 18:00 | 0.09 | | 0.13 | | 5.43 | | 1.76 | | 0.13 | | 0.73 | | 490 | | 31 | |

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0.1 | | 0.11 | | 5.15 | | 1.28 | | 0.1 | | 0.33 | | 198 | | 13 | |
| conir | 1000026429 | 1/30/97 | 2:00 | 0.09 | | 0.1 | | 6.38 | | 1.27 | | 0.12 | | 0.27 | | 156 | | 14 | |
| conir | 1000026430 | 1/30/97 | 6:00 | 0.07 | | 0.12 | | 5.9 | | 1.5 | | 0.26 | | 0.25 | STAT | 137 | | 13 | |
| conir | 1000026431 | 1/30/97 | 10:00 | 0.06 | | 0.12 | | 6.57 | | 1.57 | | 0.12 | | 0.24 | | 126 | | 29 | |
| conir | 1000026432 | 1/30/97 | 14:00 | 0.05 | | 0.11 | | 6.45 | | 1.45 | | 0.12 | | 0.24 | | 119 | | 12 | |
| conir | 1000026434 | 1/30/97 | 18:00 | 0.0185 | <.037 | 0.08 | | 5.25 | | 1.42 | | 0.09 | | 0.37 | | 330 | | 16 | |
| conir | 1000026435 | 1/30/97 | 22:00 | 0.11 | | 0.07 | | 4.38 | | 1.38 | | 0.1 | | 0.31 | | 207 | | 14 | |
| conir | 1000026436 | 1/31/97 | 2:00 | 0.1 | | 0.06 | | 5.67 | | 1.09 | | 0.1 | | 0.6 | | 515 | | 15 | |
| conir | 1000026437 | 1/31/97 | 6:00 | 0.16 | | 0.05 | | 5.74 | | 1.38 | | 0.1 | | 0.44 | | 356 | | 12 | |
| conir | 1000026438 | 1/31/97 | 10:00 | 0.11 | | 0.04 | | 5.31 | | 0.9 | | 0.1 | | 0.28 | | 205 | | 13 | |
| conir | 1000026439 | 1/31/97 | 14:00 | 0.13 | | 0.04 | | 5.3 | | 0.84 | | 0.1 | | 0.46 | | 438 | | 10 | |
| conir | 1000026446 | 1/31/97 | 18:00 | 0.09 | | 0.03 | | 4.63 | | 0.77 | | 0.08 | | 0.24 | | 251 | | 19 | |
| conir | 1000026447 | 1/31/97 | 22:00 | 0.09 | | 0.03 | | 4.39 | | 1.39 | | 0.09 | | 0.19 | | 114 | | 25 | |
| conir | 1000026448 | 2/1/97 | 2:00 | 0.12 | | 0.03 | | 4.41 | | 1.44 | | 0.09 | | 0.34 | | 245 | | 22 | |
| conir | 1000026449 | 2/1/97 | 6:00 | 0.1 | | 0.03 | | 5.33 | | 1.52 | | 0.09 | | 0.35 | | 226 | | 19 | |
| conir | 1000026450 | 2/1/97 | 10:00 | 0.09 | | 0.05 | | 6.46 | | 1.41 | | 0.08 | | 0.29 | | 107 | | 20 | |
| conir | 1000026451 | 2/1/97 | 14:00 | 0.11 | | 0.05 | | 6.84 | | 1.27 | | 0.1 | | 0.19 | | 69 | | 19 | |
| conir | 1000026458 | 2/1/97 | 18:00 | 0.0185 | <.037 | 0.05 | | 7.1 | | 0.92 | | 0.08 | | 0.051 | <.101 | 14 | | 16 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 0.04 | | 0.04 | | 7.06 | | 1 | | 0.08 | | 0.051 | <.101 | 22 | | 17 | |
| conir | 1000026460 | 2/2/97 | 6:00 | 0.08 | | 0.04 | | 7.35 | | 0.95 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 18 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0.0185 | <.037 | 0.04 | | 7.38 | | 0.97 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 18 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0.11 | | . | car97201 | . | car97201 | 0.82 | | . | car97201 | 0.29 | | 13 | | 9 | |
| conir | 1000032690 | 6/14/97 | 6:00 | 0.07 | | . | car97201 | . | car97201 | 0.71 | | . | car97201 | 0.25 | STAT | 45 | | 12 | |
| conir | 1000032691 | 6/14/97 | 10:00 | 0.06 | | . | car97201 | . | car97201 | 0.79 | | . | car97201 | 0.16 | | 12 | | 2 | <4 |
| conir | 1000032698 | 6/14/97 | 14:00 | 0.36 | | 0.03 | | 5.28 | | 1.18 | | 0.1 | | 0.38 | | 5 | <10 | 6 | |
| conir | 1000032699 | 6/14/97 | 18:00 | 0.09 | | 0.011 | | 7.45 | | 0.93 | | 0.11 | | 0.39 | | 48 | | 2 | <4 |
| conir | 1000032700 | 6/14/97 | 22:00 | 0.1 | | 0.017 | | 7.4 | | 0.86 | | 0.11 | | 0.4 | | 90 | | 7 | |
| conir | 1000032701 | 6/15/97 | 10:00 | 0.1 | | 0.008 | | 7.18 | | 0.81 | | 0.12 | | 0.32 | | 44 | | 4 | |

Results of Water Quality Mo[illegible] - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | µg/L | | µg/L | | µg/L | | µg/L | | µg/L | |
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 1.087 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0.638 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 1.18 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0.522 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0 | <1.00 | 0 | <.009 | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0 | <.5 | 0 | <.009 | 0.016 | | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0 | <.5 | 0 | <.009 | 0.016 | | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | 0 | <.5 | . | EST<.009 | . | EST<.011 | . | EST<.018 | 0 | <.2 |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | 1.056 | | . | EST<.018 | . | EST<.022 | . | EST<.036 | 0 | <.4 |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0.994 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0 | <.5 | 0.055 | | 0.016 | | 0.019 | | 0.506 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 2.063 | | 0 | <.009 | 0.014 | | 0 | <.018 | 0.548 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0.912 | | 0 | <.009 | 0.016 | | 0 | <.018 | 0.5 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.478 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 1.45 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 10.8 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 6.33 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0 | <.86 | 0 | <.016 | 0 | <.019 | 0 | <.031 | 0 | <.34 |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018439 | 5/14/96 | 6:00 | 5.94 | | 0 | <.018 | 0 | <.022 | . | IM | 1.1 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | 7.76 | | 0 | <.009 | 0 | <.011 | . | IM | 2.04 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | 4.69 | | 0 | <.009 | 0 | <.011 | . | IM | 1.05 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | 2.77 | | 0 | <.009 | 0 | <.011 | . | IM | 1.24 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | 2.77 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018444 | 5/15/96 | 6:00 | 1.18 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018445 | 5/15/96 | 12:00 | 1.06 | | 0 | <.009 | 0 | <.011 | . | IM | 0.96 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | 4.85 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018452 | 5/16/96 | 0:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018453 | 5/16/96 | 6:00 | 0 | <1.0 | 0 | <.018 | 0 | <.022 | . | IM | 0 | <.4 |
| bmpir | 1000018454 | 5/16/96 | 12:00 | 9.11 | | 0 | <.018 | 0 | <.022 | . | IM | 1.12 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | 1.18 | | 0 | <.018 | 0 | <.022 | . | IM | 1.17 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | 1.4 | | 0 | <.009 | 0 | <.011 | . | IM | 2.7 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | 1.63 | | 0 | <.009 | 0 | <.011 | . | IM | 1.16 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | 1.56 | | 0 | <.009 | 0 | <.011 | . | IM | 1.98 | |

Results of Water Quality Monito...g - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018460 | 5/18/96 | 0:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | | IM | 0 | <.2 |
| bmpir | 1000019617 | 6/24/96 | 17:00 | 0 | <1.0 | 0 | <.018 | 0 | <.022 | 0 | <.2 | 0 | <0.4 |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 11.4 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 6.44 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 3.2 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 2.27 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 5.93 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 5.17 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 1 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0.645 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0.552 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0 | 1 | 0 | <0.018 | 0 | <0.022 | 0 | <0.036 | 0.222 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0 | <.50 | 0.298 | | 0 | <0.011 | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0 | <.50 | 0 | <0.009 | 0.028 | | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0 | <.50 | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 3.95 | | 0 | <0.009 | 0.028 | | 0.019 | | 0.212 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 2.36 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0.292 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | . | est<0.50 | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | . | est<0.20 |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 2.46 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 2.32 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 2.1 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 5.95 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 1.85 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0 | <0.20 |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 2.19 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0.368 | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 1.4 | | 0.211 | | 0.022 | | 0 | <.018 | 0 | <0.20 |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 3.89 | | 0 | <0.009 | 0.027 | | 0 | <.018 | 0.333 | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 8.03 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 1.77 | |
| bmpir | 1000021090 | 8/26/96 | 22:00 | 3.4 | | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| bmpir | 1000021091 | 8/27/96 | 2:00 | 0 | <1.25 | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| bmpir | 1000021092 | 8/27/96 | 6:00 | 2.51 | | 0 | <0.018 | 0 | <0.022 | 0 | <0.036 | . | est<.2 |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 1.92 | | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 1.77 | | 0 | <.0225 | . | est<.027 | 0 | <.045 | . | est<.50 |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 1.463 | | 0 | <.0225 | . | est<.027 | 0 | <.045 | . | est<.50 |

Results of Water Quality Mo[illegible]ng - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0.954 | | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0.705 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0 | <1.00 | 0 | <.018 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0 | <.50 | 0.109 | | 0.033 | | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0 | <1.25 | 0.603 | | 0 | <.027 | 0 | <.045 | 0.665 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0.542 | | 0 | <.009 | 0.025 | | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 11.486 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 11.373 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.266 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0 | <1.00 | 0 | <.018 | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0 | ND <.50 | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 1.7 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0.22 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 2.88 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 3.4 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 1.06 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 1.08 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 1.75 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 1.12 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0.87 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0.81 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0.24 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0.82 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0.89 | | . | EST<.011 | 0 | ND <.022 | 0 | ND <.036 | 0.22 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 1.07 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.26 | |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 1.06 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.3 | |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 1.12 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.23 | |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 1.14 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.28 | |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 1.28 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 1.09 | | 0 | ND <.011 | . | EST<.022 | 0 | ND <.018 | 0.28 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 2.14 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND<.018 | 0 | ND <.20 |
| bmpir | 1000026469 | 2/4/97 | 0:00 | 2.16 | | . | EST<.009 | . | EST<.011 | . | EST<.018 | 0 | ND <.20 |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 1.85 | | 0 | ND <.009 | | EST<.011 | 0 | ND <.018 | 0.24 | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 1.97 | | 0 | ND <.009 | . | EST<.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0 | <3.28 | . | C97-228 | 0 | <.022 | . | EST1.48 | 0 | <.40 |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.724 | 0 | <.20 |

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.733 | 0 | <.20 |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.684 | 0 | <.20 |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.396 | 0 | <.20 |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.583 | 0 | <.20 |
| bmpir | 1000032693 | 6/14/97 | 22:00 | 0 | <3.45 | . | C97-228 | . | EST<.022 | . | EST<.036 | 0 | <.40 |
| bmpir | 1000032694 | 6/15/97 | 2:00 | 0 | <1.65 | . | C97-228 | . | EST<.011 | . | EST.36 | 0 | <.20 |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 8.45 | | . | C97-228 | 0 | <.011 | 0.265 | | 0 | <.20 |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 12.6 | | . | C97-228 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 5.78 | | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| condr | 1000021630 | 8/31/96 | 16:00 | . | est <.5 | 0 | <.009 | 0.027 | | 0 | <.018 | . | est<.20 |
| condr | 1000023112 | 9/27/96 | 23:00 | 1.005 | | 0.051 | | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| condr | 1000023113 | 9/28/96 | 1:00 | 2.853 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.318 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 1.968 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| condr | 1000023175 | 10/5/96 | 2:00 | 1.274 | | 0.014 | | 0.018 | | 0.02 | | 0 | <.2 |
| condr | 1000023176 | 10/5/96 | 4:00 | 0.855 | | 0 | <.009 | 0.014 | | 0.018 | | 0 | <.2 |
| condr | 1000023177 | 10/5/96 | 6:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| condr | 1000023178 | 10/5/96 | 8:00 | 0 | <.5 | 0 | <.009 | 0.014 | | 0 | <.018 | 0 | <.2 |
| condr | 1000023179 | 10/5/96 | 10:00 | 0 | <.5 | . | EST<.009 | . | EST.016 | . | EST<.018 | 0 | <.2 |
| condr | 1000023189 | 10/5/96 | 20:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.698 | |
| condr | 1000023190 | 10/6/96 | 0:00 | 2.089 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.649 | |
| condr | 1000023191 | 10/6/96 | 4:00 | 2.427 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.257 | |
| condr | 1000029148 | 3/11/97 | 8:00 | 1.15 | | 0 | <.011 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| conir | 1000018214 | 4/16/96 | 4:00 | 2.29 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018213 | 4/16/96 | 16:00 | 4.54 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018215 | 4/17/96 | 4:00 | 10.9 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018455 | 5/16/96 | 0:00 | 7.27 | | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| conir | 1000018456 | 5/16/96 | 3:00 | 1.76 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| conir | 1000018457 | 5/16/96 | 6:00 | 1.33 | | 0 | <.009 | 0 | <.011 | . | IM | 1.01 | |
| conir | 1000018458 | 5/16/96 | 12:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| conir | 1000018469 | 5/16/96 | 18:00 | 1.3 | | 0 | <.009 | 0 | <.011 | . | IM | 1.23 | |
| conir | 1000018470 | 5/17/96 | 0:00 | 1.15 | | 0 | <.009 | 0 | <.011 | . | IM | 0.85 | |
| conir | 1000018471 | 5/17/96 | 6:00 | 0.93 | | 0 | <.009 | 0 | <.011 | . | IM | 0.86 | |
| conir | 1000018472 | 5/17/96 | 12:00 | 1.06 | | 0 | <.009 | 0 | <.011 | . | IM | 0.85 | |
| conir | 1000018462 | 5/17/96 | 18:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| conir | 1000018463 | 5/18/96 | 0:00 | 2.36 | | 0 | <.009 | 0 | <.011 | . | IM | 1.99 | |
| conir | 1000018464 | 5/18/96 | 12:00 | 1.28 | | 0 | <.009 | 0 | <.011 | . | IM | 1.33 | |
| conir | 1000018473 | 5/18/96 | 18:00 | 0.92 | | 0 | <.009 | 0 | <.011 | . | IM | 1.98 | |

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 1.83 | | 0.217 | | 0.024 | | 0 | <0.018 | 0.212 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 1.25 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0 | <0.20 |
| conir | 1000020859 | 8/18/96 | 23:00 | 0 | <1.00 | 0.185 | | 0 | <0.022 | 0 | <.036 | 0 | <0.40 |
| conir | 1000020860 | 8/19/96 | 2:00 | 0 | <0.50 | 0.428 | | 0.025 | | . | est<.018 | . | est0.739 |
| conir | 1000020861 | 8/19/96 | 8:00 | 0.551 | | 0 | <0.009 | 0.025 | | . | est<.018 | . | est0.202 |
| conir | 1000020862 | 8/19/96 | 14:00 | 2.109 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| conir | 1000020947 | 8/19/96 | 20:00 | 1.9 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est0.369 |
| conir | 1000020948 | 8/20/96 | 2:00 | 0 | <0.50 | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| conir | 1000020949 | 8/20/96 | 8:00 | 4.74 | | 0 | <0.009 | 0.023 | | . | est<.018 | . | est0.434 |
| conir | 1000020950 | 8/20/96 | 14:00 | 5.9 | | 0 | <0.018 | 0 | <0.022 | . | est<.036 | . | est<0.40 |
| conir | 1000020966 | 8/20/96 | 20:00 | 0 | <0.50 | 0 | <0.009 | 0.032 | | 0 | <0.018 | 0.281 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0 | <0.50 | 0 | <0.009 | 0.025 | | 0 | <0.018 | 0 | <0.20 |
| conir | 1000020968 | 8/21/96 | 8:00 | 0.722 | | 0 | <0.009 | 0.03 | | 0 | <0.018 | 0.212 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0.924 | | 0 | <0.009 | 0.025 | | 0 | <0.018 | 0 | <0.20 |
| conir | 1000021095 | 8/26/96 | 18:00 | 0.531 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021096 | 8/26/96 | 22:00 | 3.06 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021097 | 8/27/96 | 2:00 | 1.299 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021098 | 8/27/96 | 6:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021099 | 8/27/96 | 10:00 | 0 | <1.25 | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| conir | 1000021100 | 8/27/96 | 14:00 | 0 | <1.00 | 0 | <0.018 | . | est<.022 | 0 | <0.036 | . | est<.4 |
| conir | 1000021141 | 8/27/96 | 18:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021142 | 8/27/96 | 22:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021143 | 8/28/96 | 2:00 | 0 | <1.00 | 0 | <.009 | . | est<.022 | 0 | <.036 | . | est<.40 |
| conir | 1000021144 | 8/28/96 | 6:00 | 0 | <1.25 | 0 | <.009 | . | est<.027 | 0 | <.045 | . | est<.50 |
| conir | 1000021145 | 8/28/96 | 10:00 | 1.51 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021146 | 8/28/96 | 14:00 | 1.194 | | 0 | <.009 | 0 | <.027 | 0 | <.045 | . | est<.50 |
| conir | 1000021306 | 8/28/96 | 18:00 | 1.163 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021307 | 8/28/96 | 22:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021308 | 8/29/96 | 2:00 | 0 | <.50 | 0.079 | | 0.065 | | 0 | <.018 | 0 | <.20 |
| conir | 1000021309 | 8/29/96 | 6:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021310 | 8/29/96 | 10:00 | 0 | <.50 | 0 | <.009 | 0.127 | | 0 | <.018 | 0 | <.20 |
| conir | 1000021311 | 8/29/96 | 14:00 | 0 | <.50 | 0 | <.009 | 0.036 | | 0.019 | | 0 | <.20 |
| conir | 1000021637 | 8/29/96 | 20:00 | 0 | <.5 | . | est<.009 | . | est<.011 | . | est<.018 | 0 | <.2 |
| conir | 1000021638 | 8/30/96 | 2:00 | 1.904 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| conir | 1000021639 | 8/30/96 | 8:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| conir | 1000021640 | 8/30/96 | 14:00 | 0 | <.5 | 0.882 | | 0.085 | | 0 | <.018 | 0 | <.2 |
| conir | 1000026427 | 1/29/97 | 18:00 | 2.29 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |

Results of Water Quality Monito...g - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0 | ND <.50 | 0 | ND <.02 | 0 | ND <.025 | 0 | ND <.040 | 0 | ND <.44 |
| conir | 1000026429 | 1/30/97 | 2:00 | 2.69 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026430 | 1/30/97 | 6:00 | 2.77 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026431 | 1/30/97 | 10:00 | 1.63 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026432 | 1/30/97 | 14:00 | 1.31 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026434 | 1/30/97 | 18:00 | 2.22 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026435 | 1/30/97 | 22:00 | 1.21 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026436 | 1/31/97 | 2:00 | 0.99 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026437 | 1/31/97 | 6:00 | 0 | ND <.50 | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026438 | 1/31/97 | 10:00 | 2.02 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026439 | 1/31/97 | 14:00 | 2.55 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026446 | 1/31/97 | 18:00 | 2.83 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026447 | 1/31/97 | 22:00 | 1.28 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026448 | 2/1/97 | 2:00 | 1.1 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026449 | 2/1/97 | 6:00 | 0.79 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026450 | 2/1/97 | 10:00 | 1.85 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026451 | 2/1/97 | 14:00 | 0.73 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026458 | 2/1/97 | 18:00 | 0.89 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.24 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 1.18 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| conir | 1000026460 | 2/2/97 | 6:00 | 0.85 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.25 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0 | ND <.50 | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.25 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.099 | 0 | <.20 |
| conir | 1000032690 | 6/14/97 | 6:00 | 0 | <1.78 | . | C97-228 | 0 | <.011 | . | EST.306 | 0 | <.20 |
| conir | 1000032691 | 6/14/97 | 10:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.151 | 0.646 | |
| conir | 1000032698 | 6/14/97 | 14:00 | 10.1 | | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000032699 | 6/14/97 | 18:00 | 8.49 | | . | C97-228 | 0 | <.011 | 0.071 | | 0.515 | |
| conir | 1000032700 | 6/14/97 | 22:00 | 0 | <1.64 | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000032701 | 6/15/97 | 10:00 | 5.65 | | . | C97-228 | 0 | <.011 | 0.097 | | 0 | <.20 |

Results of Water Quality Mo[illegible]g - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Prometryn value µg/L | Prometryn remark | Trifluralin value µg/L | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0 | <.06 | 0.054 | | |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0 | <.12 | 0 | <.10 | |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | . | EST<.06 | 0 | <.05 | |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | . | EST<.12 | 0 | <.1 | |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0 | <.103 | 0 | <.086 | |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0 | <.060 | 0 | <.05 | |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0 | <.060 | 0 | <.05 | |
| bmpir | 1000018439 | 5/14/96 | 6:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018444 | 5/15/96 | 6:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018445 | 5/15/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018452 | 5/16/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018453 | 5/16/96 | 6:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018454 | 5/16/96 | 12:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | . | IM | 0 | <.05 | |

Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018460 | 5/18/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000019617 | 6/24/96 | 17:00 | . | est<.2qc | 0 | <0.1 | |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 0 | <0.06 | 0.065 | | |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 0 | <0.06 | 0.053 | | |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 0 | <0.06 | 0.07 | | |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 0 | <0.06 | 0.094 | | |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0 | <0.12 | 0 | <0.10 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 0.09 | | 0 | <0.05 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | 0 | <0.06 | . | est<0.05 | |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 0 | <0.06 | 0.066 | | |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 0 | <0.06 | 0.066 | | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 0 | <0.06 | 0.052 | | |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 0 | <0.06 | 0.058 | | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 0 | <.06 | 0.062 | | Broken |
| bmpir | 1000021090 | 8/26/96 | 22:00 | 0 | <.15 | 0 | <.125 | Broken |
| bmpir | 1000021091 | 8/27/96 | 2:00 | 0 | <.15 | 0 | <.125 | Broken |
| bmpir | 1000021092 | 8/27/96 | 6:00 | 0 | <.12 | 0.058 | | |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 0 | ND <.06 | 0 | <.05 | |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 0 | ND <.15 | 0 | <.125 | Broken |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 0 | ND <.15 | 0 | <.125 | Broken |

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0 | ND <.06 | 0 | <.05 | |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0 | <.12 | 0 | <.10 | |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0 | <.15 | 0 | <.125 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0 | <.12 | 0 | <.10 | |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0 | ND <.12 | 0 | ND <.10 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 0 | ND <.06 | 0 | ND <.05 | RECIEVED PAST HOLDING TIME |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 0 | ND <.12 | 0 | ND <.10 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 0 | ND <.06 | 0.25 | | |
| bmpir | 1000026469 | 2/4/97 | 0:00 | . | EST<.06 | 0.25 | | |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 0 | ND <.06 | 0.19 | | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 0 | ND <.06 | 0.16 | | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0 | <.12 | 0.247 | | RECEIVED WARM |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0 | <.06 | 0.292 | | RECEIVED WARM |

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0 | <.06 | 0.15 | | RECEIVED WARM |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0 | <.06 | 0.182 | | RECEIVED WARM |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0 | <.06 | 0.212 | | RECEIVED WARM |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0 | <.06 | 0.154 | | RECEIVED WARM |
| bmpir | 1000032693 | 6/14/97 | 22:00 | . | EST<.12 | 0.352 | | |
| bmpir | 1000032694 | 6/15/97 | 2:00 | . | EST<.06 | 0.149 | | |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 0 | <.06 | 0.083 | | |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 0 | <.12 | 0.162 | | |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 0 | <.06 | 0.081 | | |
| condr | 1000021630 | 8/31/96 | 16:00 | 0 | <.06 | . | est<.05 | |
| condr | 1000023112 | 9/27/96 | 23:00 | 0 | <.12 | 0 | <.1 | |
| condr | 1000023113 | 9/28/96 | 1:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023175 | 10/5/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023176 | 10/5/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023177 | 10/5/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023178 | 10/5/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023179 | 10/5/96 | 10:00 | . | EST<.06 | 0 | <.05 | |
| condr | 1000023189 | 10/5/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023190 | 10/6/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023191 | 10/6/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000029148 | 3/11/97 | 8:00 | 0 | <.12 | 0 | <.10 | |
| conir | 1000018214 | 4/16/96 | 4:00 | 0 | <.060 | 0 | <.05 | |
| conir | 1000018213 | 4/16/96 | 16:00 | 0 | <.060 | 0 | <.05 | |
| conir | 1000018215 | 4/17/96 | 4:00 | 0 | <.060 | 0.109 | | |
| conir | 1000018455 | 5/16/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018456 | 5/16/96 | 3:00 | . | IM | 0 | <.05 | |
| conir | 1000018457 | 5/16/96 | 6:00 | . | IM | 0 | <.05 | |
| conir | 1000018458 | 5/16/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018469 | 5/16/96 | 18:00 | . | IM | 0 | <.05 | |
| conir | 1000018470 | 5/17/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018471 | 5/17/96 | 6:00 | . | IM | 0 | <.05 | |
| conir | 1000018472 | 5/17/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018462 | 5/17/96 | 18:00 | . | IM | 0 | <.05 | |
| conir | 1000018463 | 5/18/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018464 | 5/18/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018473 | 5/18/96 | 18:00 | . | IM | 0 | <.05 | |

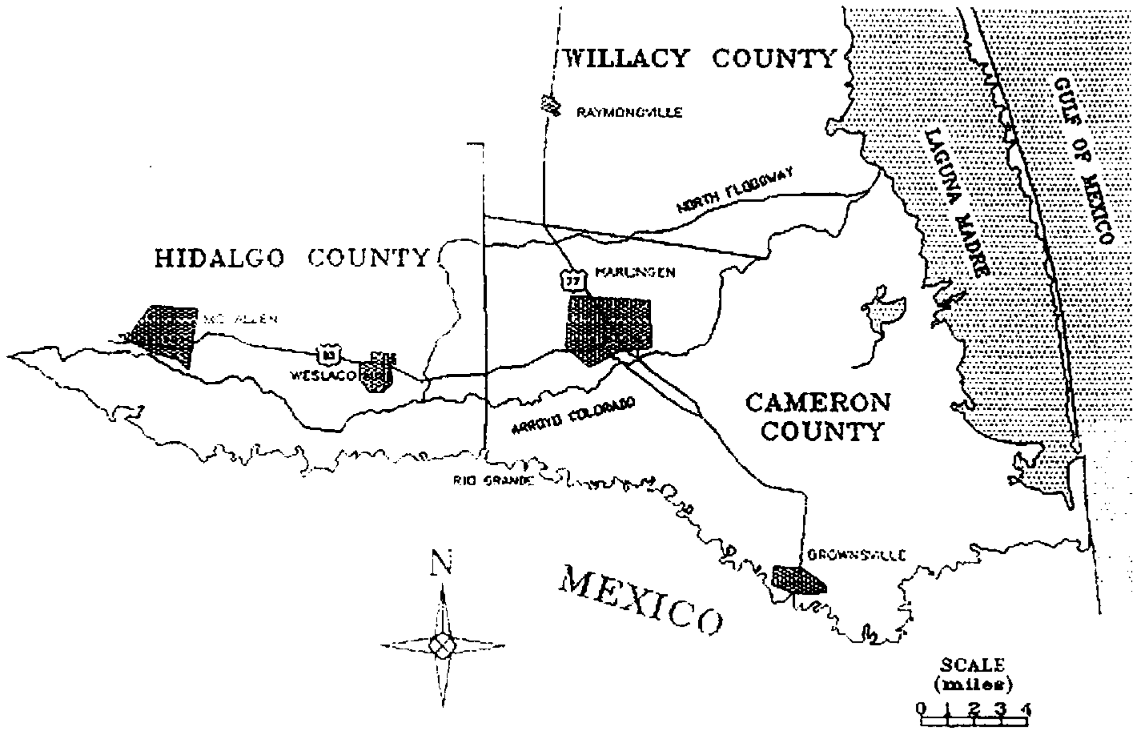
| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020859 | 8/18/96 | 23:00 | 0 | <0.12 | 0 | <0.10 | |
| conir | 1000020860 | 8/19/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020861 | 8/19/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020862 | 8/19/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020947 | 8/19/96 | 20:00 | 0 | <0.06 | 0.107 | | |
| conir | 1000020948 | 8/20/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020949 | 8/20/96 | 8:00 | 0 | <0.06 | 0.053 | | |
| conir | 1000020950 | 8/20/96 | 14:00 | 0 | <0.12 | 0 | <0.10 | |
| conir | 1000020966 | 8/20/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020968 | 8/21/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000021095 | 8/26/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021096 | 8/26/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021097 | 8/27/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021098 | 8/27/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021099 | 8/27/96 | 10:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021100 | 8/27/96 | 14:00 | 0 | <.12 | 0 | <.10 | |
| conir | 1000021141 | 8/27/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021142 | 8/27/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021143 | 8/28/96 | 2:00 | 0 | <.12 | 0 | <.1 | |
| conir | 1000021144 | 8/28/96 | 6:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021145 | 8/28/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021146 | 8/28/96 | 14:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021306 | 8/28/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021307 | 8/28/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021308 | 8/29/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021309 | 8/29/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021310 | 8/29/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021311 | 8/29/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021637 | 8/29/96 | 20:00 | . | est<.06 | 0 | <.05 | |
| conir | 1000021638 | 8/30/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021639 | 8/30/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021640 | 8/30/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000026427 | 1/29/97 | 18:00 | 0 | ND <.12 | 0 | ND <.10 | ONE BOTTLE RECEIVED BROKEN CAR# 97-0024 |

Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0 | ND <.15 | 0 | ND <.11 | |
| conir | 1000026429 | 1/30/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026430 | 1/30/97 | 6:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026431 | 1/30/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026432 | 1/30/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026434 | 1/30/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026435 | 1/30/97 | 22:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026436 | 1/31/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026437 | 1/31/97 | 6:00 | 0 | ND <.12 | 0 | ND <.10 | |
| conir | 1000026438 | 1/31/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026439 | 1/31/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026446 | 1/31/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026447 | 1/31/97 | 22:00 | 0 | ND <.12 | 0 | ND <.10 | |
| conir | 1000026448 | 2/1/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026449 | 2/1/97 | 6:00 | 0 | ND <.12 | 0 | ND <.10 | ONE BOTTLE IN TRANSIT |
| conir | 1000026450 | 2/1/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026451 | 2/1/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026458 | 2/1/97 | 18:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026460 | 2/2/97 | 6:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0 | <.06 | 0.165 | | RECEIVED WARM |
| conir | 1000032690 | 6/14/97 | 6:00 | 0 | <.06 | 0.187 | | RECEIVED WARM |
| conir | 1000032691 | 6/14/97 | 10:00 | 0 | <.06 | 0.144 | | RECEIVED WARM |
| conir | 1000032698 | 6/14/97 | 14:00 | 0 | <.06 | 0.081 | | |
| conir | 1000032699 | 6/14/97 | 18:00 | 0 | <.06 | 0.103 | | |
| conir | 1000032700 | 6/14/97 | 22:00 | 0 | <.06 | 0.069 | | |
| conir | 1000032701 | 6/15/97 | 10:00 | 0 | <.06 | 0.115 | | |

# *Appendix C: Arroyo Colorado Water Quality Web Site and Report*

# Arroyo Colorado Water Quality Database




As part of the project, *NPS Prevention in the Arroyo Colorado Watershed*, the Texas Agricultural Extension Service, under the direction of Dr. Guy Fipps, assembled a database of available water quality data on the Arroyo Colorado. This report summarizes the contents of the database and it's suitability for accessing the water quality status and trends of the Arroyo Colorado. This web site is located on computers of the Agricultural Engineering Department at Texas A&M University.

Questions? Comments? Email us at g-fipps@tamu.edu

---

Texas A&M University System

*Texas Agricultural Extension Service*
*Agriculture Engineering Department*
*Dr. Guy Fipps*
*217 Scoates Hall*
*College Station, TX 77843-2121*

Office: (409) 845-7454

# Maps of the Arroyo Colorado River

The following maps were created by Craig Pope at Texas A&M University. These maps detail the Arroyo, it's tributaries, and the tidal and non-tidal sections.

# Water Quality Indicators

Water Quality Indicators were analyzed for each of the three stations listed below. For Station 13036, data for each parameter was available for years 1984 to 1993. For Station 13071 and 13074, data for each parameter was availale for years 1984 to 1994. Graphical charts for seven parameters are listed under the respective station.

| Station 13036 | Station 13071 | Station 13074 |
|---|---|---|
| **(on Tributary Segment 2200)** | **(on Tidal Segment 2201)** | **(on Non-Tidal Segement 2202)** |
| Dissolved Oxygen | Dissolved Oxygen | Dissolved Oxygen |
| Nitrate | Nitrate | Nitrate |
| Dissolved Phosphorous | Dissolved Phosphorous | Dissolved Phosphorous |
| Total Phosphorous | Total Phosphorous | Total Phosphorous |
| Sulfate | Sulfate | Sulfate |
| Fecal Coliform | Fecal Coliform | Fecal Coliform |
| Chloride | Chloride | Chloride |

# Arroyo Colorado River Water Quality Database

The Arroyo Colorado River Water Quality Database is now currently available as queriable on-line program or as a file that can be downloaded. The downloaded files are the original database files that were created with Paradox 4.0 and can be easily read with this version or a later version such as Paradox 7 for Windows 95 and Windows NT.

The water quality data is split into four databases, including one for each tidal and non-tidal segment of the river, one for the tributaries to the Arroyo Colorado River and one for a subsequent toxic study. The following links detail the information found in these databases.

Watershed Station Listing by Location and Segment Identification
Field Descriptions of Files in Databases
List of Routine Water Quality Parameters in Database

## DATABASES

**For On-line Query**

Database for Segment 2200

Database for Station Location for Segment 2200

Database for Segment 2201

Database for Station Location for Segment 2201

Database for Segment 2202

Database for Station Location for Segment 2202

**For Downloading**

Database for Segment 2200

Database for Station Location for Segment 2200

Database for Segment 2201

Database for Station Location for Segment 2201

Database for Segment 2202

Database for Station Location for Segment 2202

Database for Toxin Study

Database for Station Location for Toxin Study

# Analysis of the Arroyo Colorado Water Quality Database

FINAL REPORT

(http://arroyo.tamu.edu/arroyo/progreport.html)

October 1997

by

Guy Fipps, P.E.
Associate Professor and Extension Agricultural Engineer
Texas Agricultural Extension Service
Texas A&M University System
College Station, TX 77843-2117

PREPARED IN COOPERATION WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was 60% financed through $443,630 in grant funds
from the U.S. Environmental Protection Agency
through the Texas Natural Resource Conservation Commission

## EXECUTIVE SUMMARY


As part of the project: NPS Prevention in the Arroyo Colorado Watershed, the Texas Agricultural Extension Service assembled a database of available water quality data on the Arroyo Colorado, which is included on this Web Site. This report summarizes our analysis of the data base to determine its usefulness in defining water quality problems and trends in the Arroyo. Here we report on the long-term trends of 7 water quality indicators:

dissolved oxygen,
sulfate,
nitrate,
fecal coliform,
dissolved phosphorous,
total phosphorous,
and chloride;

and we review the toxic substance data.

While approximately 48 monitoring stations were used on the Arroyo during the period of record (1982-1994), only a few were used consistently and have complete sets of data. For this first analysis, we chose the three stations that had the most complete and longest periods of record. One station is located in the non-tidal reach, one in the tidal reach, and the third on the North Floodway, a tributary to the Arroyo.

We first compared the detected levels to the Surface Water Quality Criteria (SWQC). Since SWQC do not exist for phosphorous and nitrate, we used the Texas Natural Resource Conservation Commission's screening levels for total and dissolved phosphorous, nitrogen, and the safe drinking water standards for nitrate. The results were that all 7 parameters may be potential water quality problems in the Arroyo based on this criteria.

For the toxic substance data base, we found that most of the data is useless for determining water quality due to the sensitivity of the testing methods used; i.e., the lowest limit of the testing method is above the concentration found and above the standards established for aquatic life and human health protection. While the presence of about 55 substances were detected in the Arroyo during approximately 10 years of sampling and analysis, there were only two substances that exceeded standards, lead and cadmium, which occurred once in 1986 at one location.

Numerous analysis results from sediment and fish tissue samples are included in the database for which no standards exists. However, concentrations of 13 toxic substances appear elevated in the sediment and tissue samples. Sampling and analysis for toxic substances were performed erratically during the 10 year period considered here; and no trends can be determined.

## INTRODUCTION

This study was conducted as part of the project *NPS Prevention in the Arroyo Colorado Watershed,* funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). In addition to the Texas Agricultural Extension Service (TAEX), other participating agencies were the Texas Institute for Applied Environmental Research (TIAER), the Natural Resources Conservation Service (NRCS) and the Southmost Soil and Water Conservation District.

The project was better known as the *"Section 319 Arroyo Colorado Project."* Task 3.1 of the project work plan directed TAEX to organize available water quality data on the Arroyo Colorado into a database. This task was completed and the database is provided on this Web Site. The database is divided into two sections: routine water quality parameters and toxic substances. In this report, we examine 7 parameters which are often used as water quality indicators and for which sufficient analysis results were completed:

dissolved oxygen,
sulfate,
nitrate,
fecal coliform,
dissolved phosphorous,
total phosphorous, and
chloride.

In addition, we provide a summary analysis of the Toxic Substances Data Base.

## WATER QUALITY DATA BASE

In assembling the Arroyo Colorado Database, we first contacted a number of state and federal agencies and requested any and all available water quality data collected for the Arroyo Colorado including data in electronic format and any written reports or publications. These contacts then lead to others. However, we limited our search to data files and publications that contain actual data that were not duplicated elsewhere.

The most extensive bibliography on water resources in the Lower Rio Grande Valley was put together by Judd (1994). A number of publications were found that contain actual water quality data and are included in Bibliography section of this progress report. Additional data requested but not provided to us: the *Coastal Monitoring Impact Study* conducted by the General Land Office, and *1993-94 Shrimp Farm Impacts Study and Coastal Fisheries Database* from the Texas Parks and Wildlife Department.

We found that most of the water quality data that has been collected since 1982 is already contained in the **Surface Water Quality Monitoring (SWQM)** *Paradox* database. This database is a consolidation of water quality data collected by the TNRCC, USGS and International Boundary and Water Commission (IBWC), which is maintained by the TNRCC. From SWQM, we extracted the water quality data for the Arroyo Colorado and its tributaries and reorganized it into our database which is also in *Paradox* format which is located on this web site. In doing so, we simplified the database structure in order to facilitate the analysis of the information and developed a series of maps and tables to aid in its use.

Similarly the TNRCC's database on the *Rio Grande Toxic Substances Study for the Arroyo Colorado* was simplified and included in our database. It contains toxic substance data collected by the TNRCC from ten monitoring stations. The database contains some data from 1983, and data from 1986 to through 1994.

## THE ARROYO COLORADO

The Arroyo Colorado flows through Hidalgo, Cameron and Willacy County in the Lower Rio Grande Valley of Texas into the Laguna Madre. The Arroyo Colorado waters include possible base flow from the Rio Grande River, urban runoff, agricultural runoff, irrigation return flow, municipal and industrial wastewater and effluent. Perennial flow is supported by municipal discharges from the cities of Mission, McAllen, Pharr, Donna, Harlingen, and San Benito (TDWR, 1981). During flood events, water is diverted from the Rio Grande into the Arroyo and North Floodway

### Segment Numbers

See the Maps section of this Web Site for the location of the Arroyo and its three segments. The segment descriptions are as follows:

**Segment 2200** identifies the tributaries to the Arroyo along segments 2201 and 2201, including the North Floodway. The North Floodway forks from the Arroyo in Hidalgo County below Weslaco, flows through the northwest portion of Cameron County into Willacy County, and joins the Arroyo near the Laguna Madre.

**Segment 2201** (tidal segment) is east of FM. 510 and runs from a point 100 m downstream of Cemetery Road, south of Port Harlingen to the confluence with the Laguna Madre.

**Segment 2202** (non-tidal segment) is west of F.M. 510. It runs from F.M. 2602 in Hidalgo County to a point 100 m downstream of Cemetery Road, south of Port **Harlingen Monitoring**

### Stations

For routine monitoring, some 48 locations have been used for sampling of the Arroyo Colorado and tributaries over the period of record (see Appendix A and Table E-1). However, most of these locations were used for only for short periods of time and, in some cases, for single sampling events. Currently, 4 stations are being used for routine sampling and analysis: stations

13071, 13074, 13081 and 13782. For toxic analysis, a total of 10 stations have been used for various durations, although only 2 have been used consistently.

For this analysis, we chose the 3 stations that had the longest and most complete data sets of routine (i.e., not toxic) water quality data. These are:

Station 13036 on tributary segment 2200,
Station 13071 on tidal segment 2201, and
Station 13074 on non-tidal segment 2202.

## WATER QUALITY PARAMETERS AND LEVELS IN THE ARROYO COLORADO

### Routine Water Quality Parameters

Texas has established Surface Water Quality Criteria (SWQC) for many water bodies in the state based on designated uses (see Title 30, Chapter 307 of the Texas Administrative Code). The Arroyo Colorado is designated as "contact recreational," and SWQC have been established for 5 parameters on segment 2201 and for 7 parameters on 2202 (Table 1). Segment 2200, a tributary, has no SWQC. On the charts for Segment 2200 (see Charts section of this Web Site), we show the SWQC of segment 2202 to facilitate comparison of levels with other two segments of the Arroyo.

For a number of other parameters, the TNRCC has established "screening levels" which are used as a general indicator of potential water quality concerns. These are based on best professional judgement. For the parameters considered here, these are 0.1 mg/l for dissolved phosphorus, 0.01 for total phosphorus, and 1 mg/l for total nitrogen. For nitrates, we also used the EPA Safe Drinking Water Standard of 10 mg/l in our analysis..

Analysis Results by Individual Stations

In the Charts Section of this Web Site are figures which show the levels of each of the 7 parameters by station and sampling event during the period of record between 1982-1994. The actual sampling dates at each station varied from year to year. Location of the bars on these figures correspond to the dates the samples were taken. The results of this analysis are summarized below and in Table 2 and 3.

| **TABLE 1:** Surface Water Quality Criteria (SWQC) for the Arroyo Colorado on Segment 2201 (Tidal) and Segment 2202 (Non-Tidal). | | |
|---|---|---|
| **Parameter** | **Segment 2201** | **Segment 2202** |
| Dissolved Oxygen (mg/L) | 4.0 | 4.0 |
| Temperature (F) | 95.0 | 95.0 |
| PH | 6.5-9.0 | 6.5-9.0 |
| Chloride (mg/L) | ------ | 1200 |
| Sulfate (mg/L) | ------ | 1000 |
| Total Dissolved Solids (mg/L) | ------ | 4000 |
| Fecal Coliform (#/100 mL) | 200 | 200 |

| **TABLE 2:** Potential water quality problems in the Arroyo Colorado by segment number for 7 parameters considered in this report. | | |
|---|---|---|
| **SEGMENT 2200 (NORTH FLOODWAY)** | **SEGMENT 2201 (TIDAL)** | **SEGMENT 2202 (NON-TIDAL)** |
| Nitrate | Nitrate | Nitrate |
| Dissolved Phosphorous | Dissolved Phosphorous | Dissolved Phosphorous |
| Total Phosphorous | Total Phosphorous | Total Phosphorous |
| Sulfate | Sulfate | Sulfate |
| Chloride | Chloride | ------ |
| ------ | Dissolved Oxygen | Dissolved Oxygen |
| Fecal Coliform | ------ | Fecal Coliform |

| |
|---|
| **Table 3:** Comparison of 7 water Quality indicators to established screening criteria and standards in the Arroyo Colorado. |
| **Sulfate** levels at station 13036 (Floodway) exceeded the SWQC (non-tidal) in 8 of the 26 samples taken over the 10 years of record. Station 13074 had lower sulfate levels which exceeded the SWQC in only 3 of the 50 samples taken from 1982-1994. Sulfate levels for Station 13071 (tidal segment) had very high peeks, wide fluctuations in levels, and exceeded the SWQC 1000 mg/l (non-tidal criteria) in 37 of the 53 samples over the 13 years of record. |
| **Chloride** followed a similar pattern as sulfate. The non-tidal station 13074 only exceeded the SWQC two times during the 13 years of record. High chloride levels wide side fluctuations occurred at station 13071 (tidal), where only 5 of the samples were below the 1200 mg/l SWQC. Station 13036 (Floodway) had 12 out of 27 samples above the non-tidal SWQC. |
| **Fecal coliform** levels at station 13036 have fallen from peak levels (2000 to 3000 counts/100 ml) in 1985 and 1986 to well below the SWQC 1991 and 1992, but then rose again in 1993. At the tidal station 13071, only three samples were higher than the SWQC, the last occurring in early 1987. However, station 13074 (non-tidal) continues to show very high spikes of above 5000 counts/100 ml and large fluctuations. |
| Total **nitrogen** levels (ammonia + nitrate) nearly always exceed the TNRCC screening level of 1 mg/l. However, when compared to the EPA Safe Drinking Water Standards, nitrate values were are almost always well below the 10 mg/l standard. Station 13036 recorded the highest nitrate levels and greatest fluctuations when compared to the other two stations. |
| **Dissolved oxygen** values never fell below the SWQC of 4 mg/l at station 13036 (Floodway) or station 13074 (non-tidal). However, at station 13071 (tidal), low dissolved oxygen levels occurred in 35 of the 132 samples taken over the 13 year period, and levels fluctuated from almost 0 to over 17 mg/l. A high frequency of low oxygen levels occurred most recently in 1992. |
| **Dissolved phosphorous** levels are compared to TNRCC screening levels since no SWQC or drinking waters standards exist for phosphorous. Relative low levels of dissolved phosphorous occurred at stations 13036 and 13071 (Floodway and tidal), although most samples exceeded this screening level. Station 13074 (non-tidal) saw consistently higher dissolved phosphorous levels, whose peaks have remained fairly constant since 1986. |
| **Total phosphorous** followed the same pattern as with dissolved phosphorous, with the lowest levels occurring at stations 13036 and 13071 (Floodway and tidal). Station 13074 (non-tidal) had the highest levels, with a single very high spike occurring in 1985, 1990, and 1994. |

Correlation with Flow

We also examined the correlation of flow in the Arroyo to the detection levels of each parameter. We obtained flow measurement data from the International Boundary and Water Commission (IBWC) for stations 13071 (tidal) and 13074 (non-tidal). As no exact flow data is available for station 13036 (Floodway), we used the scale reported with the samples: 0 (no flow) to 5 (high flow).

This analysis was run for dissolved oxygen, fecal coliform, nitrate, sulfate, dissolved phosphorous and total phosphorous. The results are given in Table 3. No correlation existed (R2 < 0.1, correlation > $\pm$0.4) between flow and nitrate, dissolved and total phosphate, and fecal coliform.

Dissolved oxygen showed some correlation to flow at station 13036 with $R^2$ =0.19 and correlation coefficient of 0.44. Flow vs. sulfate regression statistics give an $R^2$ =0.55 and correlation coefficient of -0.75 suggesting that sulfate levels are consistent, thus concentrations increase with decreasing flow and vise-versa. However, to fully investigate the effect of flow on substance concentrations, a more rigorous sampling protocol should be implemented.

| **Table 4:** Summary Table of Regression and Correlation Analysis for the Arroyo Colorado (flow may be correlated to level detected for $R^2 > 0.1$ and correlation > + 0.4). | | | | | | |
|---|---|---|---|---|---|---|
| | **Station Number** | | | | | |
| | **13036** | | **13071** | | **13074** | |
| | R square | Correlation | R square | Correlation | R square | Correlation |
| Flow vs Dissolved Oxygen | 0.1948 | 0.4414 | 0.0001 | -0.0086 | 0.0868 | -0.2946 |
| Flow vs Fecal Coliform | 0.0521 | 0.2283 | 0.0006 | 0.0257 | 0.0208 | 0.1444 |
| Flow vs Nitrate | 0.0417 | 0.2041 | 0.0172 | 0.1313 | 0.0013 | -0.036 |
| Flow vs Sulfate | 0.0054 | 0.0732 | 0.3656 | -0.6046 | 0.5602 | -0.7485 |
| Flow vs Dissolved Phosphorous | 0.0009 | 0.0311 | 0.0001 | -0.0032 | 0.0008 | 0.0286 |
| Flow vs Total Phosphorous | 0.1176 | -0.3429 | 0.0004 | -0.0206 | 0.0072 | 0.0849 |

## TOXIC SUBSTANCES DATA BASE

The Toxic Substances Data Base (included on this Web Site) contains data collected by the TNRCC's *Rio Grande Toxic Substances Study for the Arroyo Colorado.* The data base contains data collected from tem monitoring stations in 1983 and 1986 through 1994. Here, we have restructured the data base to facilitate it's use. Tables 5, 6 and 7 summarized our review of this data base.

For toxic substances, Texas has established standards for aquatic life protection (criteria in water for 34 substances) and for human health protection (criteria in water for water and fish for 60 substances). These can be found in Title 30, chapter 307 of the Texas Administrative Code (these regulations may be accessed through the INTERNET at TNRCC's Web Site).

Use of this data for evaluating the water quality status of the Arroyo is limited by the same factors discussed above for the surface water data. These include improper analytic method (i.e., lowest detection limit being above the standard) and erratic sampling frequency. For example, only 8 of the 37 substances analyzed for in Segment 2200 exceeded the test detection lower limit, 18 out of 49 for Segment 2201, and about 20 out of 55 for segment 2202. Of these, only 2 substances exceeded established standards: lead and cadmium, during one sampling event in 1986.

Numerous sediment and tissue samples were also taken and are reported in the data base. While no standards exist, the following substances appear elevated: for sediment, chlordane, DDE, PCB, oil and grease, Nickel, lead, DDT, dieldrin, zinc, silver; for tissue, chlordane, DDE, DDT.

**Table 5.** Toxic Substance Standards and Number of Substances Analyzed in the Arroyo Colorado Toxic Substance Data Base.

| |
|---|
| STANDARDS EXIST FOR: |
| Aquatic life protection - criteria in water<br>34 substances |
| Human health protection - criteria in water for water and fish<br>60 substances |
| SUBSTANCES TESTED FOR: |
| Segment 2202 - non-tidal segment<br>55 substances |
| Segment 2201 - tidal segment<br>49 substances |
| Segment 2200 - tributaries<br>37 substances |

**Table 6.** Analysis Results of the Arroyo Colorado Toxic Substance Data Base.

| Substances exceeding test detection "lower" limits | Sediment | Tissue |
|---|---|---|
| Segment 2202 | 18 | 20 |
| Segment 2201 | 18 | 6 |
| Segment 2200 | 8 | 0 |
| **Toxic concentrations, in water, that exceed standards** | | |
| Lead (07/14/1986 | | |
| Cadmium (07/14/1986) | | |

**Table 7.** Toxic Substances in Sediment and Tissue Samples that Appear Elevated.

| Sediment | Tissue |
|---|---|
| Chlordane Lead | Chlordane |
| DDE DDT | DDE |
| PCB's Dieldrin | DDT |
| Oil & Grease Zinc | |
| Nickel Silver | |


## ACKNOWLEDGMENTS

The following TAEX personnel contributed to this report:

Carrie Bausch, Student Worker
David Smith, Extension Assistant
Kim Sucek, former Student Worker
Ed Wilson, former Extension Graduate Assistant

We also wish to express our appreciation to the following individuals and agencies for their assistance in providing data and information used in this study:

Blucher Institute
Nick Kraus

Bureau of Economic Geology
Tom Tremblay

General Land Office
Bruce Smith

International Boundary and Water Commission
Yvette McKenna

Texas Department of Health
R. J. Hutton
Kirk Wiles

Texas Institute for Applied Environmental Research
Larry Hauck

Texas Natural Resource Conservation Commission
Kerry McCullough
Gayle Rothe
Angela Miller
Alisha Reinmund
James McKinney
Steve Neimeyer
Jack Davis
Trey Murph
Jim Davenport
Charles Bear
Patrick Roques
John Hinijosa
Steve Tidwell
Charles Webster
Jerry Blizzard

Texas Natural Resources Information System
Charlotte Aanstoos
Charles Palmer

Texas Parks, Fish and Wildlife Department
Roy Kleinsasser
Dave Buzan
Charles Sanchez
Tom Shultz
Paul Fore
Larry Ditto

Texas State Soil and Water Conservation Board
Lupe Pinto
Lennie Winkelman
Suzanne Cardwell
Bo Spoonts

United States Geological Service
Lloyd Woolsey
George Ozuna

University of Texas-Pam American
Armondo Lopez
Dorene Garza
Dr. Frank Judd
Don Hockaday

U.S. Bureau of Reclamation
Nick Palacios

U.S. Environmental Protection Agency
Evan Horning

## BIBLIOGRAPHY

Baker, Roger C. and O. C. Dale. Groundwater Resources of the Lower Rio Grande Valley Area, Texas. Bulletin 6014, Volume I. February 1961. Texas Board of Water Engineers. pp. 81.

Davis, Jack R. Intensive Survey of the Arroyo Colorado Segment 2201, August 22-25, 1983. IS-69. Texas Department of Water Resources. January 1985. 41 pp. + appendices.

Davis, Jack R. Intensive Survey of the Arroyo Colorado Segment 2201. IS-61. Texas Department of Water Resources. May 1984. 22 pp. + appendices.

Eaton, David J. and David Hurlbut. Challenges in the Binational Management of Water Resources in the Rio Grande/Rio Bravo. U.S. - Mexican Policy Studies Program, Policy Report No. 2, 1992. Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin. 138 pp.

Gamble, Lawrence R., Gerry Jackson and others. Organochlorine, Trace Element, and Petroleum Hydrocarbon Contaminants Investigation of the Lower Rio Grande Valley, Texas, 1985-1986. U. S. Fish and Wildlife Service. October 1988. 34 pp. + appendices.

International Water and Boundary Commission. Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and Its Tributaries Along the Boundary Portion Between the United States and Mexico. November 13, 1992. 246 pp.

International Boundary and Water Commission. Flow of the Rio Grande and Related Data, 1993. Water Bulletin Number 63. IBWC. 132 pp.

International Boundary and Water Commission (IBWC). Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico. Final Report, September 1994. 250 pp.

Judd, F. W. Final Project Report: Report of Literature Review on Discharges from the Rio Grande and Arroyo Colorado and Their Impact. The University of Texas-Pan American Coastal Studies Laboratory. April 1994. 59 pp.

Judd, F. W. Water-Related Natural Resources of the Lower Rio Grande Valley of Texas: An Annotated Bibliography. University of Texas-Pan American. April 1994. 219 pp.

Lacewell, Ronald D., John R.C. Robinson and others. Estimated Agricultural Benefits Attributable to Drainage and Flood Control in Cameron County, Texas. Final Report prepared for the U. S. Department of Agriculture, Soil Conservation Service, Temple, and U. S. Army Corps of Engineers, Galveston. February 19. 1990. 131 pp.

Miyamoto, S. L.B. Fenn, and D. Swietlik. Flow, Salts, and Trace Elements in the Rio Grande: A Review. Texas Water Resources Institution (TWRI), Texas A&M University System, College Station. MP 1764, July 1995. 30 pp.

Texas Water Commission. Regional Assessment of Water Quality in the Rio Grande Basin. Texas Water Commission. GP 92-02, November 1992. 207 pp. + appendices.

Texas Department of Water Resources. Report 245, Chemical and Physical Characteristics of Water in Estuaries of Texas. October 1974 - September 1975. April 1980. 224 pp.

Texas Water Commission. The State of Texas Water Quality Inventory. 11th Ed. Texas Water Commission. LP 92-16, August 1992. 682 pp.

Texas Department of Health. Fish Tissue Sampling Data: 1980 - 1993. 224 pp.

Texas Water Commission and Texas State Soil and Water Conservation Board. 1990 Update to the Nonpoint Source Water Pollution Assessment Report for the State of Texas. Texas Water Commission. March 1991. 61 pp. + appendices.

Texas State Soil and Water Conservation Board. Executive Summary: A Comprehensive Study of Texas Watersheds and Their Impacts on Water Quality and Water Quantity. January 1991. Texas State Soil and Water Conservation Board. 311 North 5th, Temple, Texas 76503. 208 pp.

Texas State Soil and Water Conservation Board and Soil and Water Conservation Districts. 1988 & 1990 Agricultural/Silvicultural Nonpoint Source Assessment. 1990.

Twidell, Steve R. Intensive Surface Water Monitoring Survey for Segment 2201, Arroyo Colorado-Tidal. IMS-72. Texas Department of Water Resources. February 1979 (reprinted March 1984). 24 pp + appendices.

U. S. Department of the Interior, Bureau of Reclamation. Lower Rio Grande Basin Study, Working Document. Fiscal Year 1993. 56 pp. + appendices.

U. S. Department of the Interior, Bureau of Reclamation. Lower Rio Grande Basin Study, Working Document, Economic Data. November 1993. 34 pp.

U. S. Environmental Protection Agency. R-EMAP, Regional Environmental Monitoring and Assessment Program. EPA/625/R-93/012. September 1993. 82 pp.

U. S. Environmental Protection Agency. Region 6 State/EPA Ambient Toxicity Monitoring Program. Region 6 Environmental Services Division. Dallas, Texas 75202-2733. July 1994. 43 pp.

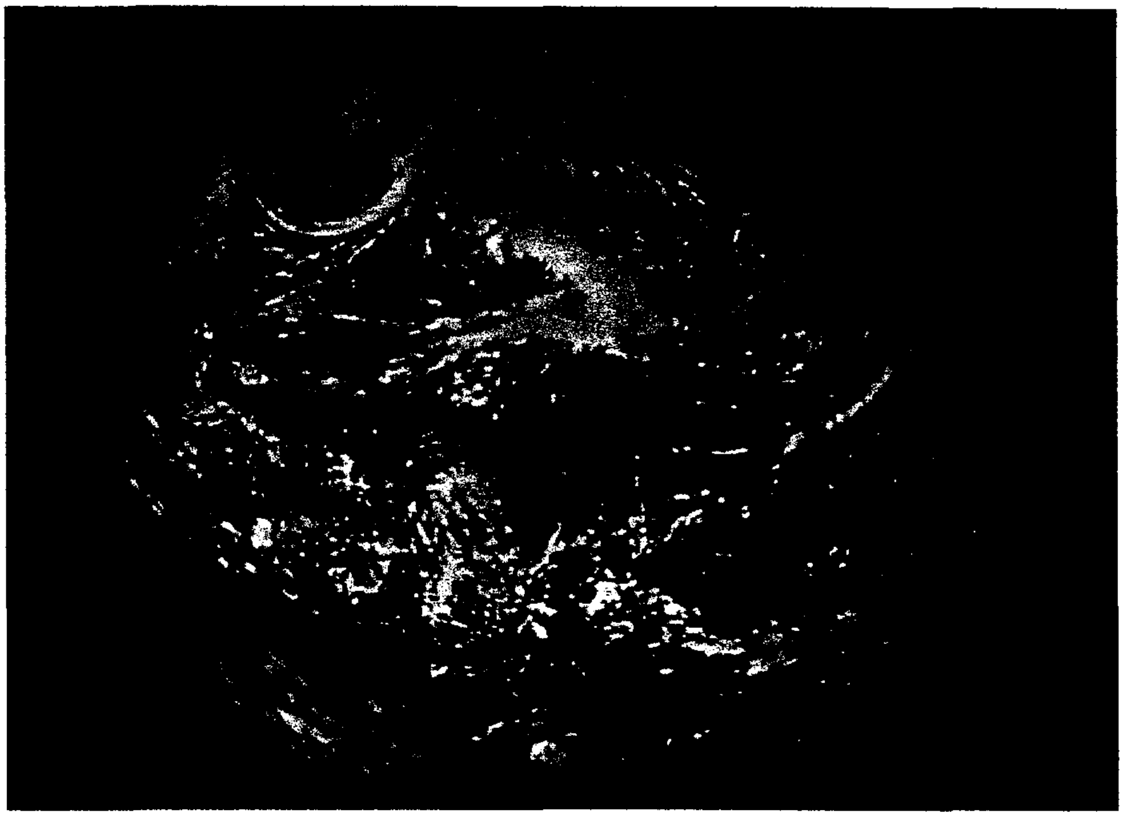
U. S. Geological Survey. Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Association with Irrigation Drainage in the Lower Rio Grande Valley and Laguna Atascosa National Wildlife Refuge. Texas, 1986-87. U. S. Geological Survey, Water - Resources Investigations Report 87-4277. 1988. 89 pp.

# *Appendix D: Fact Sheets and Educational Materials*

# Appendix D: Fact Sheets and Educational Materials

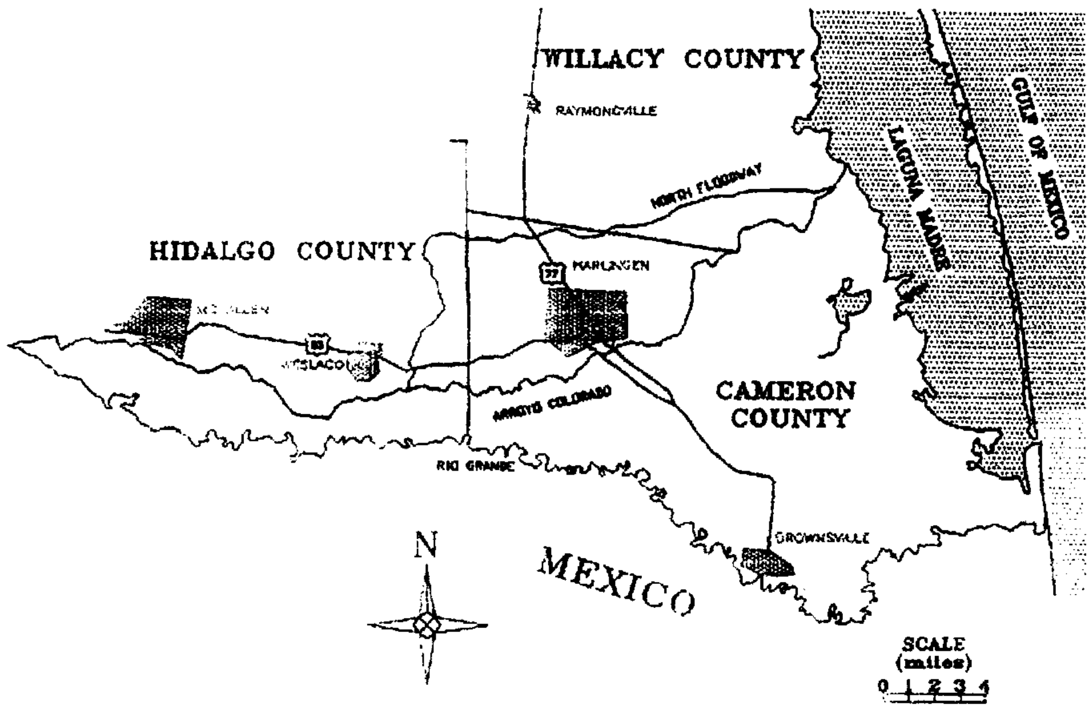
# Help Yourself, Help the Environment

Today, you are learning about the benefits of no-till and reduced tillage for improving crop yields, reducing costs and maintaining soil productivity. However, there are other benefits - like helping our environment. Conservation tillage helps reduce runoff from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including conservation tillage, and proper water and nutrient management, you will be doing your part to help protect the water quality in the Valley.



## *The Arroyo Colorado*

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.



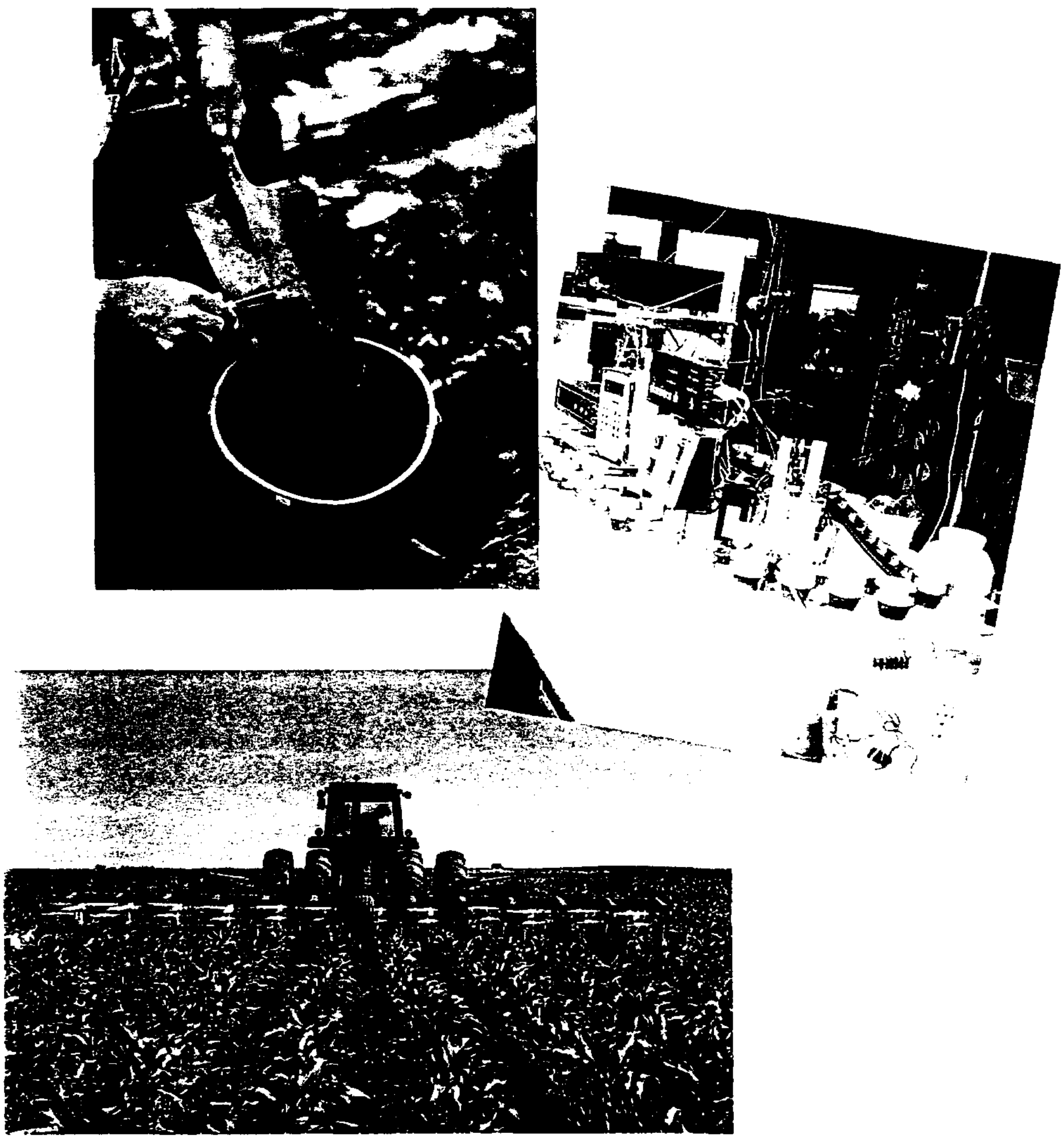

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. Today's meeting is one of several educational events supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Texas Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://arroyo.tamu.edu.

Texas Agricultural Extension Service

The Texas A&M University System

# Soil Fertility and Fertilizer Management



Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

**Prepared in Cooperation with the U.S. Environmental Protection Agency**

The preparation of this report was 60% financed through $443,630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

# SOIL FERTILITY AND FERTILIZER MANAGEMENT[1]

Mark L. McFarland and Guy Fipps

A sound soil fertility program is the foundation upon which a profitable farming business must be built. Agricultural fertilizers are necessary for producing abundant, high quality food, feed and fiber crops. Using fertilizer nutrients in the proper amounts and applying them correctly are both economically and environmentally important to the long-term profitability and sustainability of crop production. The fertilizer nutrients that have potential to become groundwater or surface water pollutants are nitrogen and phosphorus. In general, other commonly used fertilizer nutrients do not cause concern as pollutants.

**Nitrogen**

Nitrogen (N) is a part of all plant and animal proteins. Therefore, human survival depends on an abundant supply of N in nature. A crop well supplied with N can produce yields many times greater, with the same amount of water, than one starved for N. Properly fertilized crops use both N and water more efficiently, thus improving environmental quality and profitability.

The only part of the soil that supplies N to a crop is organic matter, since soil minerals do not contain N. In general, only 20 to 30 pounds per acre of N are supplied annually for each 1 percent of organic matter in the soil. Since this N is released slowly and generally is not matched to crop needs, additional N is required. Soil testing is important to determine additional N needs. Relying on generalized recommendations for crop N requirements often results in poor N use efficiency and excessive application.

Decomposition of organic matter results in simpler inorganic N forms such as ammonium ($NH_4^+$) and nitrate ($NO_3^-$). Commercial inorganic fertilizers containing nitrogen also contain one or both of these forms. Both forms of nitrogen are soluble in soil water and readily available for plant uptake. Since clay soil particles are negatively charged and attract positively charged nutrients, much like a magnet.

Ammonium is positively charged and is attracted to and held by negatively charged soil particles, it does not readily move down through the soil with rainfall or irrigation water. Nitrates, on the other hand, are not attracted to soil particles, move downward with soil water and can be leached into groundwater.

Soil microbes can convert ammonium -N fertilizer to the nitrate form. Thus if nitrogen fertilizer is improperly applied to

[1]Extension Soil Fertility Specialist and Extension Agricultural Engineer, respectively,Texas Agricultural Extension Service, Texas A&M University System, College Station, Texas 77843

soils that have high infiltration rates, it can be leached through the root zone to contaminate groundwater. In addition these fertilizers can be dissolved and transported in rainfall runoff to contaminate surface waters. Excessive nitrate concentrations in water can accelerate algae and herbaceous plant growth in streams and lakes, resulting in oxygen depletion. Nitrate concentrations above a certain level in drinking water may be injurious to the health of some animals or human infants.

Even nontoxic nitrate levels may lower human resistance to environmental stresses and interfere with normal metabolism. Likewise, ammonia ($NH_3$) from fertilization, or from the natural breakdown of organic matter in lake bottoms, can kill fish.

**Phosphorus**

Phosphorus (P), like nitrogen, is essential for plant growth. Naturally occurring P exists as soluble inorganic phosphate ions, soluble phosphate, particulate phosphate or mineral phosphate. The mineral forms of phosphorus (calcium, iron and aluminum phosphates) are low in solubility and are readily adsorbed to clay particles.

The immediate source of phosphorus for plants is that which is dissolved in the soil solution. A soil solution containing only a few parts per million of phosphate ions is usually considered adequate for plant growth. The phosphate ions are absorbed from the soil solution and used by plants. These ions may be replaced from soil minerals, soil organic matter decomposition or applied fertilizers. Many soils have too little available P to support the needs of modern, high yielding crops without additional P fertilization.

Phosphate ions are not readily soluble. Most of the ions are either used by living plants or adsorbed to sediment, so the potential of their leaching to groundwater is low. That portion of phosphate bound to sediment particles is virtually unavailable to living organisms, but becomes available as it detaches from sediment. Only a small part of the phosphate moved with sediment into surface water is immediately available to aquatic organisms. However, additional phosphate can slowly become available through biochemical reactions. The slow release of large amounts of phosphate from sediment layers in lakes and streams could cause excessive algae blooms and excessive growth of herbaceous plants, thereby affecting water quality.

**Nutrient Best Management Practices**

Best management practices (BMPs) are defined as those practices or combinations of practices which are the most effective practical means of preventing pollution generated by nonpoint sources, or reducing it to a level compatible with good water quality. Because erosion and runoff are the two major ways nonpoint source pollutants move into surface water resources, practices which reduce erosion or runoff are considered BMPs. Similarly, practices which limit the buildup of nutrients that leach to groundwater and practices which ensure the safe use of agricultural chemicals also are considered best management practices. Both economic and environmental concerns should be considered.

1. Test the soil for nutrient status and pH to:

    - determine the amounts of additional nutrients needed to reach designated yield goals, and the amount of lime needed to correct soil acidity problems;

- avoid excessive fertilization and reduce nutrient losses via leaching and runoff; and identify other yield limiting factors such as high levels of salts or sodium which may affect soil structure, infiltration rates, surface runoff and, ultimately, groundwater quality.

2. Base fertilizer applications on:

   - realistic yield goals and moisture prospects;

   - past fertilization practices; and previous cropping history.

3. Manage low soil pH by liming according to the soil test to:

   - reduce soil acidity;

   - improve fertilizer use efficiency;

   - improve decomposition of crop residues and soil aggregate formation; and

   - enhance the effectiveness of certain soil applied herbicides.

4. Time nitrogen applications to:

   - correspond closely with crop uptake patterns;
   - increase nutrient use efficiency; nd

   - minimize leaching and runoff losses.

5. Inject fertilizers or incorporate surface applications when possible to:

   - increase accessibility of fertilizer nutrients to plant roots;

   - reduce volatilization losses of ammonia N sources; and

   - reduce nutrient losses from erosion and runoff.

6. Use animal manure and organic materials:

   - when available and economically feasible;

   - to improve soil tilth, water holding capacity, and soil structure; and

   - to recycle nutrients and reduce the need for inorganic fertilizers.

7. Rotate crops when feasible to:

   - improve total nutrient recovery with different crop rooting patterns;

   - reduce erosion and runoff; and

   - reduce diseases, insects and weeds.

8. Use cover crops and legumes where possible to:

   - reduce erosion and nutrient losses;

   - maintain residue cover on the soil surface; and

- replace part or all of crop needs for supplemental N fertilizer.

9. Control nutrient losses in erosion and runoff by:

   - using appropriate structural controls;

   - adopting conservation tillage practices where appropriate;

   - properly managing crop residues;
   - implementing other soil and water conservation practices where possible.

10. Skillfully handle and apply fertilizer by:

    - properly calibrating and maintaining application equipment;

    - properly cleaning equipment and disposing of excess fertilizers, containers and wash water; and

    - storing fertilizers in a safe place.

**Benefits of Soil Testing**

Soil testing is the key to a sound fertility management program. A soil test is a chemical analysis of the soil which determines whether levels of essential plant nutrients are sufficient to produce a desired yield. When not taken up by a crop, some nutrients, particularly nitrogen, can remain in the soil or be lost from the soil by leaching or volatilization.

**Soil Sampling**

Proper soil sample collection is the most important step in obtaining a useful soil test. Samples must be taken very carefully to be representative of the area sampled. Generally one "composite" soil sample should be collected from each uniform area (field or part of a field) of 10 to 40 acres. A composite sample is obtained by combining 10 to 15 individual soil cores taken randomly across each uniform area. These cores are placed in a clean plastic bucket, thoroughly mixed and then about 1 pint is sent to the laboratory for testing.

Individual soil cores can be taken using a regular spade, soil auger or soil sampling tube. First, scrape any plant litter from the surface and then make the core or boring 6 inches deep. When using a spade, dig a V-shaped hole and take a 1-inch slice from the smooth side of the hole. Next take a 1 by 1-inch core from the center of the shovel slice. By collecting 10 to 15 individual cores across the area, one can ensure that the soil test results will be representative of the site.

Clearly label each sample with a sample identification number. That number should correspond to the one listed on the sample identification sheet submitted with the sample to the laboratory. Place all samples, information sheets and payment into a sturdy paper box for shipment to the laboratory. Be sure to keep a record of the dates and locations the samples were collected. Complete sampling instructions and sample bags can be obtained from your local County Extension office.

To ensure good results, follow these recommendations:

- Submit samples immediately after

collection or allow them to air dry before storing.

- Never use heat to dry a sample.

- Keep accurate records of the area represented by each sample.

- Avoid sampling areas such as small gullies, depressions, terraced waterways and unusual spots.

- When sampling fertilized fields, do not sample in the fertilized band.

- Do not use metal buckets or containers with any residue in them since it might affect test results.

Soil test bags and instruction sheets may be obtained from the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory in College Station, Texas, or from various private laboratories across the state. Contact your local County Extension Agent for more information.

**Interpreting Soil Test Results**

On a typical soil test analysis, values for each nutrient are reported "very low", "low", "medium", "high" or "very high". These ratings do not evaluate the soil's capacity to produce yields, but indicate the relative availability of the nutrient and likelihood of a crop response to fertilization. An economic response to fertilization can usually be expected for soils with very low nutrient levels, while those with high or very high levels will generally show little or no response.

The nutrient requirements of crops depend largely on the type of crop and the yield goal. Based on many years of research, the average nutrient demands of most crops per unit of yield are reasonably well known. Table 1 shows the typical nitrogen fertilizer requirements for several major crops. When a crop and yield goal are specified on the soil information sheet, a fertilizer recommendation is provided.

Table 2 provides typical fertilizer recommendations for most major crops. These are maximum rates which would be recommended for a soil testing **very low** in nitrogen, phosphorus and potassium. Most fields will have higher residual levels of some nutrients, and fertilizer recommendations provided by the laboratory will be adjusted accordingly based on the soil test.

Other best management practices which should be followed when utilizing any fertilizer material include:

1. Time applications as closely as possible to periods of crop nutrient need.

2. Avoid applications when the ground is saturated or when the potential for heavy rainfall is great.

3. Band or incorporate fertilizers into the soil if possible to conserve nutrients and improve availability.

4. Avoid applications on steep (15%) slopes.

5. Uses practices to control sediment losses.

Table 1. Suggested Nitrogen Fertilization Versus Crop Yield (Minus Nitrate-Nitrogen Identified by Soil Test)

| Crop | Yield Goal/Acre | Pounds N/Unit Weight |
|---|---|---|
| Corn | 75 - 99 bu | 1.0/bu |
| | 100 - 149 bu | 1.1/bu |
| | 150 - 200 bu | 1.2/bu[1] |
| Cotton | 0.5 - 2.5 bales | 0.1/lb of lint[2] |
| Grain Sorghum | 1500 - 8000 lbs | 2.0/cwt[3] |
| Wheat | 20 - 100 bu | 1.5/bu grain only[4] |
| | | 2.0/bu grazing/grain |
| Coastal Bermuda | 1 - 6 cuttings | 100/cutting |
| | (2 - 12 tons) | 50/ton[5] |

[1]One bushel of 8.4 and 9.0% crude protein corn would remove 0.75 and 0.80 lbs N, respectively. However, greater N recommendations (1.2 lbs) are required because of inefficiencies of N uptake and utilization.

[2]Actual fertilizer recommendations for cotton are 25% higher than crop requirements because of inefficiencies. (1 bale or 500 lbs x 0.1 = 50 lbs N, etc.)

[3]One cwt of 10.0 and 11.0% crude protein grain sorghum would remove 1.60 and 1.76 lbs N, respectively. However, recommendations are based on 2.0 lbs N/cwt.

[4]One bushel of 12.5% crude protein wheat removes about 1.2 lbs N. Because of inefficiencies of N uptake and utilization, 1.5 lbs N/bu is recommended for grain production only. However, 2.0 lbs N/bu is recommended for both grazing and grain production, followed by topdressing additional nitrogen at approximately 0.75 to 1.0 lb N/bu after livestock removal and prior to jointing.

[5]One ton of 12.5% crude protein hay contains 40 lbs of N (2000 x 2.0% N). However, higher N fertilization (50 lbs N/ton) is suggested because of inefficiencies of N uptake and utilization. Recommendations are based on the assumption that two (2) tons of forage are produced per cutting. If this is not the case, it may be better to base N fertilization on 50 lbs N/ton.

Table 2. Crop Yield Goals Versus Suggested Fertilization

| CROP | Yield Goal | Suggested Fertilization[1] N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| | | (lbs/A) | (lbs/A) | (lbs/A) |
| Corn | 75 - 99 bu/A | 75 - 100 | 60 | 80 |
| | 100 - 149 bu/A | 110 - 165 | 80 | 130 |
| | 150 - 200 bu/A | 180 - 240 | 80 | 140 |
| Cotton | 1.0 bale/A | 40 | 40 | 30 |
| | 1.5 bales/A | 60 | 60 | 50 |
| | 2.0 bales/A | 80 | 80 | 80 |
| | 2.5 bales/A | 100 | 80 | 80 |
| Grain Sorghum | 1500 - 2000 lbs/A | 30 - 40 | 20 | 20 |
| | 2000 - 4000 lbs/A | 40 - 80 | 40 | 80 |
| | 4000 - 6000 lbs/A | 80 - 120 | 60 | 100 |
| | 6000 - 8000 lbs/A | 120 - 160 | 80 | 120 |
| Peanuts | dryland | 20 | 40 | 40 |
| | Irrigated | 20 | 60 | 60 |
| Soybeans | dryland/irrigated | 10 | 40 | 125 |
| Wheat (grain only) | 20 - 30 bu/A | 30 - 45[2] | 20 | 20 |
| | 30 - 40 bu/A | 45 - 60 | 40 | 30 |
| | 40 - 60 bu/A | 60 - 90 | 40 | 40 |
| | 60 - 80 bu/A | 90 - 120 | 60 | 60 |
| | 80 - 100 bu/A | 120 - 150 | 60 | 60 |

[1]Soils testing high in both phosphorus and potassium may require supplemental nitrogen only to attain yield goals. (Generally, no economic response to potassium fertilization would be expected west of I-35. Exceptions may be under intensively managed irrigated cropping systems or crops grown on sandy soils.)

[2]Grain Production Only: The above N rates for wheat are based on 1.5 lbs N/bushel. Apply approximately 1/3 of the total N suggested above preplant and topdress the remaining N prior to jointing.
Grazing and Grain Production: Apply 2.0 lbs N/bu preplant (for higher yield goals or on sandy soils, split N between preplant and late fall applications). Topdress with an additional 0.75-1.0 lb N/bu after livestock removal and prior to jointing.

Table 2. (cont.) Crop Yield Goals Versus Suggested Fertilization

| CROP | Yield Goal | Suggested Fertilization[1] N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| | | (Lbs/A) | (Lbs/A | (Lbs/A) |
| Alfalfa | Non-irrigated, annually | 20 | 60 | 120 |
| | Irrigated; 6T/A | 20 | 100 | 160 |
| | Irrigated; 8 - 12 T/A | 20 | 140 | 200 |
| Clover | Annually | 20 | 80 | 120 |
| | Sod seeded | 20 | 80 | 120 |
| | With ryegrass/small grains | 40 | 80 | 120 |
| Wheat | Light grazing | 60[2] | 60 | 60 |
| | Moderate grazing | 80 | 80 | 120 |
| | Heavy grazing | 80 | 80 | 120 |
| Sorghum/ Sudan | 1 cutting or light grazing | 80[3] | 40 | 40 |
| | 2 cuttings or med. grazing | 80 | 60 | 60 |
| | 3 cuttings or heavy grazing | 80 | 80 | 80 |

[1]Generally, no economic response to potassium fertilization would be expected west of I-35. Exceptions may be under intensively managed irrigated forage systems or crops grown on sandy soils.

[2]Fertilizer rates suggested for grazing wheat pastures are for the higher rainfall, eastern one-third of Texas or where irrigation is possible. Dryland rates for all grazing intensities should be reduced by approximately 10% for each 50-mile increment west of I-35 to compensate for decreasing annual rainfall. Topdress with additional N in late fall and again in late winter at the following rates per acre per application: **Light** (50 lbs N), **Moderate** (60 lbs N) and **Heavy** grazing (80 lbs N) with adjustments for available moisture as suggested above for dryland production.

[3]Adjust fertilizer rates according to rainfall expectations as suggested above for wheat. For 2 cuttings of hay or moderate grazing, topdress with an additional 60 lbs N/A after first cutting or graze down. Where a third cutting or heavy grazing is possible, topdress with another 40 lbs N/A.

Texas Agricultural Extension Service
The Texas A&M University System

# PEST AND BENEFICIAL ARTHROPODS

# OF COTTON

# IN THE LOWER RIO GRANDE VALLEY

# PEST AND BENEFICIAL ARTHROPODS

# OF COTTON

# IN THE LOWER RIO GRANDE VALLEY

by

Alton N. Sparks, Jr. and John W. Norman, Jr.

**Prepared in Cooperation with the U.S. Environmental Protection Agency**

The preparation of this report was 60% financed through $443,630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

# *PEST AND BENEFICIAL ARTHROPODS OF COTTON IN THE LOWER RIO GRANDE VALLEY*

Alton N. Sparks, Jr. and John W. Norman, Jr.[1]

Cotton is an important agricultural crop in the Lower Rio Grande Valley (LRGV). Our environment is well suited for cotton production and, unfortunately, is also well suited for the numerous arthropod pests that attack cotton and can severely impact yield. Cotton is subject to attack and damage by arthropods from planting through harvest; although the greatest potential for damage in the LRGV is from early squaring through boll maturity. In addition to the many arthropods that can damage cotton, cotton fields are also home to numerous arthropods which attack these pests. Although control of pests with insecticides is sometimes needed, good pest management relies on correct identification and a thorough understanding of the pests' biologies combined with a coordinated implementation of multiple management strategies. Insecticides generally are an effective tool in a management plan, but should be viewed as a last resort and used only when necessary.

Proper selection and use of pesticides, only when needed, will result in better control and lower production costs. However, there are other benefits - like helping our environment. Integrated pest management combined with proper pesticide application practices will ensure that the chemicals go and stay where they are needed, so as not to contribute to runoff [1]from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including integrated pest management, proper chemical application, and sprayer calibration, you will be doing your part to help protect the water quality in the LRGV.

The purpose of this publication is to familiarize the reader with the appearance, basic biology and management of the major pests of cotton in the LRGV. Additional sections on occasional pests and beneficial organisms are included to aid in the identification of some of the more common of these organisms. For additional information on the pests of cotton and insecticide selection, should insecticide use become necessary, refer to Texas Agricultural Extension Service publications B-1210 (Managing Cotton Insects in the LRGV) and B-1210A (Suggested Insecticides for Managing Cotton Insects in the LRGV).

**Early-season Pests**

Early-season is the first few weeks of the season from planting until the first appearance of 1/3-grown squares. The major early-season insect pests of cotton in the LRGV are overwintered boll weevils, fleahoppers, and occasionally silverleaf whiteflies. Management of pests during the early season is targeted at obtaining early fruit set, which leads to early maturity and avoidance of potentially severe late season pest pressure. Occasional early-season pests include aphids, cutworms, thrips and spider mites.

---

[1]Associate Professor and Extension Entomologist, and Extension Agent-IPM, Texas A&M university Agricultural Research and Extension Center, Weslaco, 78596-8344

**Mid-season and Late-season Pests**

**Mid-season** is the 6-week fruiting period following the appearance of the first 1/3-grown squares. Proper crop management and frequent field inspection for pests and beneficials will eliminate unnecessary insecticide applications during this period. The major concern during this period is maintaining adequate fruit set and preserving beneficial insect populations.

**Late-season** is the remainder of the production season when the major concern is boll protection. Monitoring boll set and maturity will aid in making pest management decisions in the late-season period. The primary concern during this period is protection of immature bolls, that eventually will be harvested, but are young enough to still be susceptible to damage by insects.

The major mid- and late-season pests of cotton in the LRGV are the boll weevil and silverleaf whitefly. The bollworm/budworm complex is also considered a potential major pest at these times, but does not occur with the frequency of boll weevils and whiteflies. Occasional mid- and late-season pests include aphids, spider mites, beet armyworm, and loopers.

**Fruit Development and Susceptibility to Damage**

Cotton will generally start setting fruit at the fourth to sixth true leaf node. The process of fruit development starts in the terminal with the initiation of the development of squares. The size of square gives an indication of the age and susceptibility of the individual square to damage by certain pests. Square sizes generally referred to in pest management are pinhead squares, matchhead squares and 1/3 grown squares. Approximately 21 days after initiation of a square, blooming and fertilization occurs, resulting in formation of a boll. Once a boll is formed, it requires approximately 45 days for the fiber to develop and mature and the boll to open. Boll age also effects the susceptibility to damage by pests, with the greatest potential for damage occurring early in boll development.

**Figure 1**. Small square shown relative to pin head and match head.

## MAJOR PESTS

### Boll Weevil

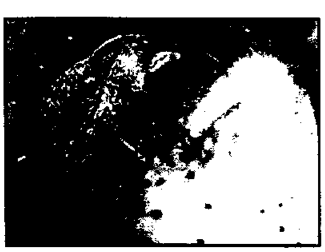


**Figure 2**. Adult boll weevil on a cotton square.

The adult weevil is about 1/4-inch long, grayish brown, and has a prolonged snout with chewing mouthparts at its tip. The presence of two distinct spurs on the lower part of the first segment of the front leg will distinguish the boll weevil from other weevils with which it might be confused. Both adult and immature weevils damage cotton. Adults cause damage by feeding on fruiting structures and through oviposition in these structures. Female weevils oviposit eggs in squares and young bolls. The female chews a hole into the square or boll (similar to

**Figure 3**. Boll weevil grub inside of a cotton square.

feeding) and then places an egg inside the fruit and refills the hole. This generally results in a characteristic 'wart' at the oviposition site. The egg hatches in about three days, and the legless white grub begins feeding within the fruit. Bracts on damaged squares typically open, which is referred to as flaring. Flared squares usually fall off the plant after the first molt of the grub, but may wither and dry while stuck on the plant. Grubs develop through three instars and a pupal stage within the fruit. The adult emerges inside the fruit and chews its way out. The complete life cycle requires 15 to 25 days. In managing weevils it is important to be aware that only the adults are exposed to potential control with insecticides. Thus, weevil management generally emphasizes cultural manipulations to reduce the density of overwintering adults and prevention or delay of damaging populations until late in the season. Once weevils become well established in a field, multiple insecticide applications generally are required to prevent severe economic damage.

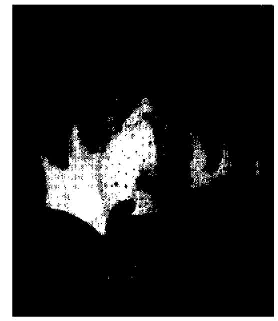


**Figure 4**. Boll weevil oviposition puncture on a cotton square.

**Overwintered boll weevil**

Overwintered boll weevils enter cotton early in the season. They occur in very low numbers and successful oviposition and development of larvae does not occur until the first squares are about 1/4-inch in diameter (1/3-grown). Insecticides applied at this time will help suppress boll weevil population buildup until after peak bloom. This allows the plant to set a large number of bolls early, while minimizing adverse effects on mid- and late-season beneficial insects.

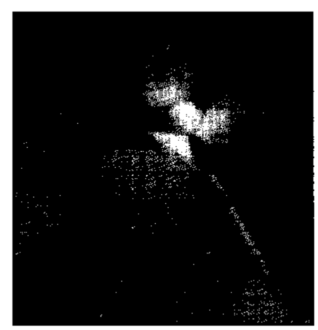


**Figure 5**. Flared cotton square.

**Management and decision making.** The value of making automatic insecticide applications for overwintered weevils has not been demonstrated in all areas of the Valley. **Research has shown that 40 overwintered boll weevils per acre can produce a damaging first generation population.** The first generation of boll weevils emerges and becomes active during the early fruiting period.

If weevils are noticed and the field has a history of heavy weevil infestation, early-season control applications may be economically feasible. The first application should be applied no earlier than 1/3-grown squares. The second application should be applied 3 to 5 days later if weevils continue moving into the field. When two early-season applications of insecticides were made in research and field tests in areas with heavy weevil pressure, damaging boll weevil levels were delayed 10 to 12 days. However, in other areas where similar spray tests were conducted, subsequent damaging weevil levels were not delayed because of unknown factors. These applications should not be made in fields where population buildup in past years has not occurred and weevils are not found. Avoid making the final overwintered boll weevil insecticide application within 10 days of bloom to allow beneficial insect and spider populations time to reestablish in anticipation of bollworm infestations. Also, as boll weevils move into the edges of fields from overwintering sites, insecticide treatments may be effective when limited to treating along brush lines or corners where boll weevils are concentrating. By treating only these "hot spots," producers provide a refuge for beneficials in the non-treated areas and these beneficials can move back into treated areas more quickly.

### Mid- and Late-season Boll Weevil

**Management and decision making.** To monitor damage by weevils, make weekly inspections of 100 1/3-grown squares randomly collected from four or more representative locations in the field from various portions of the plant. **If boll weevil-damaged square levels reach 15 to 25 percent from the time of squaring to peak bloom, the economic threshold level has been reached and an insecticide application is necessary.** Because insecticides only control adult weevils, established populations may require repeated treatments at 5-day intervals. This can also occur when weevil populations are high in a general area and field-to-field movement allows for rapid reinfestation. Under extremely heavy populations, it may be necessary to shorten application intervals to 3 days. However, if proper cultural considerations have been made under the short-season production system, the number of mid- to late-season insecticide applications can be greatly reduced and insecticide use may not be necessary.

**Figure 6**. Cotton boll size relative to days after bloom. (R. Parker)

Although boll weevils show a distinct preference for squares, they will also attack developing bolls. In late-season when few squares are present, young bolls can be damaged by weevils. The potential for damage to bolls decreases with the age of the individual boll. Relatively little damage by weevils occurs in bolls more than 12 days old, particularly if an adequate supply of younger fruit forms is available. Thus, once the latest bolls targeted for harvest have reached 12 days, there no longer exists a reason to control weevils (for that years crop).

### Cotton Stalk Destruction

One of the most useful tools available to cotton producers for management of boll weevils is the complete, timely destruction of cotton at the end of the season. Research has repeatedly shown that weevils entering overwintering at the end of the normal production season have much less chance of surviving the winter and infesting the next season's crop as compared to weevils that are allowed to feed on cotton in the fall and early winter months. Although adult weevils can feed on pollens from a variety of plants, only cotton provides the large acreage needed for development of large overwintering populations. Thus, through complete destruction of the crop residue at the end of the growing season, combined with elimination of escapes and volunteer cotton throughout the winter, LRGV cotton producers can reduce the level of weevil populations they will battle the following season.

## Silverleaf Whitefly

Silverleaf whitefly (SLWF), formerly known as sweetpotato whitefly (strain B), has been a pest of cotton in the LRGV since 1990. As adult whiteflies move into cotton fields, they congregate near the terminal of plants where most eggs are layed. The whitefly life cycle begins as a tiny yellow-orange, cigar-shaped egg laid on end in groups or clusters usually on the underside of leaves. The tip of the egg turns tan or dark prior to hatching. A small, nearly clear crawler stage emerges from the egg, finds a suitable place on the leaf, and inserts its needle-like mouthparts into the tissue and begins to feed. The crawler is the only mobile immature. The scale-like immatures continue to feed, molt and grow as immobile insects until they emerge as adults (there is a short non-feeding pupal stage prior to adult emergence). The entire life cycle of SLWF lasts from 12 to 30 days, or longer, depending on temperature. On cotton, in the heat of the summer, SLWF can complete its life cycle in about 2 weeks. Because of its high reproductive rate (short life cycle, high egg production, high survival), SLWF can build large populations over a relatively short period.

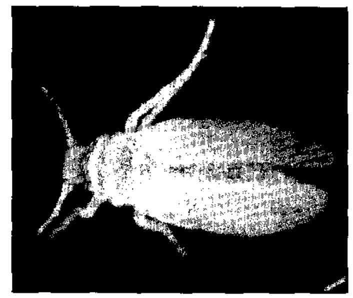


**Figure 7**. Silverleaf whitefly adult.

**Figure 8**. Silverleaf whitefly immatures on the underside of a cotton leaf.

Damage by SLWF ranges from honeydew deposits on open cotton lint, to reduced plant vigor, premature defoliation and reduced quantity and quality of lint. Experience in the LRGV has shown that in the heaviest infestations, yield reductions can be severe with losses of more than 500 pounds of lint per acre. Whiteflies also affect lint quality parameters such as reduced micronaire and length. Viral disease transmitted to cotton by SLWF has been a severe problem in some countries, but has not been a problem in Texas.

**Management and decision making.**
Sampling for SLWF is generally conducted by examining the underside of the third leaf from the top of the plant and counting adults, and/or counting immatures on the underside of the fifth leaf from the top. Older leaves are used for sampling immatures because whitefly immatures do not move during development and the plant continues to grow, thus, older nymphs are generally found lower on the plant than eggs and adults. **Currently, thresholds for whitefly treatment in cotton are not set. However, adult SLWF populations that have been observed to cause damage have ranged from 5 to 15 adults per leaf. Immature populations of 1 per square inch maintained for at least 6 weeks have been shown to cause yield losses of approximately 20 pounds per acre.**

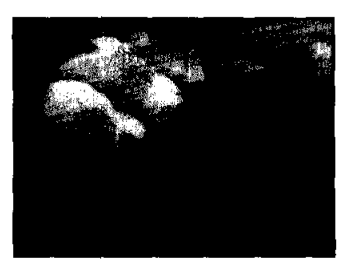


**Figure 9**. Sooty mold fungus on cotton lint.

Cultural controls have provided the best approaches to management of the SLWF in the LRGV and form the foundation for effective integrated management of this pest. Proper management of SLWF in cotton actually starts in winter and spring vegetables and planting of the cotton. Management of the pest on alternate host crops (e.g. melons and cabbage) and separation of cotton from these source populations plays a key role in reducing potential problems in cotton. Timely destruction of vegetable crop residue that harbors active SLWF populations is one of the simplest methods of lowering potential levels of SLWF infestations in nearby cotton fields.

Host plant resistance is another key element of managing SLWF in cotton. In general, smooth-leafed varieties have far fewer whiteflies than hairy-leafed cotton varieties. Yield data from tests conducted in the LRGV show that higher yields can be achieved if smooth-leafed varieties are grown when SLWF are a threat to the crop.

Several species of naturally occurring parasites and predators will attack SLWF and can aid in the management of infestations. However, these beneficials must be preserved to maximize impact on SLWF populations. Applications of broad spectrum insecticides decrease the role of beneficial insects in managing SLWF. The impact of beneficials can also be easily overwhelmed by the presence of a nearby, large source population of SLWF.

Tests conducted in the LRGV during the last several years have shown that insecticidal control of SLWF populations is achievable, but is most efficacious and cost effective when used as part of an integrated management program. Insecticides alone have been found to be ineffective, or cost prohibitive, when populations are large and other management strategies are not being employed. Insecticidal control is not an effective stand-alone strategy for management of this pest. However, with a proper integrated management approach, it has been possible to manage SLWF in cotton in the LRGV with minimal insecticidal inputs.

## Cotton Fleahopper

Adult cotton fleahoppers are about 1/8-inch long and pale green. Nymphs resemble adults but lack wings and are light green. They move very rapidly when disturbed. Adults move into cotton from host weeds when cotton begins to square. In the LRGV, wooly croton likely serves as the primary spring host for fleahoppers and elimination of these weeds can reduce pest pressure. Adults insert small yellowish-white eggs under the bark of the cotton plant. These eggs hatch in about one week. Both adults and nymphs suck sap from tender portions of the plant, including the terminal and small squares. Generally, squares are most susceptible to damage from pinhead through matchhead size. Small squares fed on by fleahoppers turn bronze to black and are shed by the plant. These are referred to as blasted squares.

**Figure 10**. Cotton fleahopper adult. (W. Sterling)

**Management and decision making.** After cotton begins producing the first small squares (4-to 6-leaf stage), examine the main stem terminal buds (about 3 to 4 inches of plant top) of 25 randomly selected plants at each of four or more locations across the field. Examine plants closely as fleahoppers are highly mobile and will move around stems, effectively hiding from detection. **During the first 3 weeks of squaring, 15 to 25 cotton fleahoppers (nymphs and adults) per 100 terminals may cause economic damage.** As plants grow and increase fruit load, larger populations of fleahoppers may be tolerated without economic yield reduction. Fleahoppers are not considered a threat to cotton once sufficient bolls and large squares are present to produce the desired crop. Care should be taken not to apply insecticides early in the blooming period as this will result in destruction of beneficial insects, possibly inducing an outbreak of bollworm or tobacco budworm.

**Figure 11**. Cotton fleahopper nymph on a small square.

**Figure 12**. Small square damaged (blasted) by cotton fleahopper.

## Bollworm and Tobacco Budworm

Bollworm and tobacco budworm larvae are similar in appearance and cause similar damage. Full grown larvae are about 3/4 inches long and vary in color from pale green to pink or brownish to black, with longitudinal stripes along the back. They can be distinguished from other caterpillars attacking cotton by the presence of microspines covering their cuticle or skin. These microspines, which look like tiny spines under magnification, give these larvae a generally rough appearance.

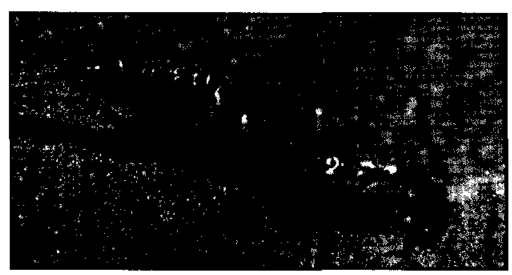


**Figure 13**. Bollworm/tobacco budworm larvae on cotton leaf.

Tobacco budworm and bollworm moths are attracted to and lay eggs in cotton that is producing an abundance of new growth. Moths usually lay eggs singly on the top of young, tender terminal leaves in the upper third of the plant. Sometimes moths deposit eggs on squares, bolls, stems and, in general, on lower portions of the plant. This may occur when cotton plants are stressed and have little new growth or during periods of high temperatures and low humidity. Detection and control of eggs and small larvae are more difficult when eggs are deposited in these locations. Eggs are pearly white to cream colored and about half the size of a pinhead. These should not be confused with looper eggs which are flatter and usually laid singly on the underside of leaves. Eggs hatch in 3 to 4 days, turning light brown before hatching. Young larvae usually feed for a day or two on tender leaves, leafbuds and small squares in the plant terminal before

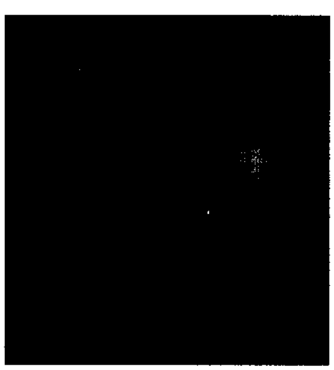


**Figure 14**. Bollworm/tobacco budworm eggs in cotton terminal.

moving down the plant to attack larger squares and bolls. When small larvae are in the upper third of the plant they are most vulnerable to natural mortality and to insecticides.

Budworms are less susceptible to certain insecticides than bollworms, but generally are less numerous than bollworms until mid-June. Once applications of certain insecticides are used to control bollworms and budworms, the percentage of budworms in the population increases with each additional application because of higher mortality in the bollworm population. Aphid and other secondary pest infestations may increase following bollworm/budworm sprays, especially when pyrethroids are used.

**Figure 15**. Cotton square damaged by larvae.

**Management and decision making.** A major objective of a well-planned IPM program is to avoid having to treat for bollworm and tobacco budworm. Naturally occurring parasites, predators and, to a certain extent, weather conditions often suppress bollworm and budworm populations. Making applications of broad spectrum insecticides, for any reason, can eliminate beneficial arthropods and lead to the outbreak or resurgence of a variety of secondary or induced pests, including bollworm and budworm.

To monitor bollworm and budworm populations and damage, examine 100 green squares for larvae and damage, and 100 plant terminals for eggs and small larvae. In addition, examine a few plants in each field for eggs, larvae and damage on lower leaves, stems and fruiting forms. If eggs or larvae are found in these lower structures, intensify sampling in these areas.

**Prior to initial chemical application.** Fields should be scouted at least once a week prior to bloom and twice weekly thereafter. Fields should be divided into four quadrants and 25 green squares (1/2-grown or larger) should be selected at random in each quadrant. If fields are larger than 100 acres, additional scouting sites should be added to the sample.

**Before bloom, the economic threshold is reached when larvae are present and 15 to 25 percent of the green squares are worm-damaged.**

**After bolls are present, the economic threshold has been reached when larvae are present and 8 to 10 percent of the green squares have been worm-damaged.** When sampling, avoid selecting flared or yellowed squares.

**After initiation of insecticide applications.** The fields should be checked closely 2 to 3 days following the first application. **The economic threshold level has been reached when bollworm eggs and 6 to 10 young larvae are found per 100 terminals (3,000 to 4,000 young larvae/acre) and 5 percent of the squares and small bolls have been injured by small bollworms and budworms.** If control has not been obtained, another application will be necessary immediately.

**Bt Transgenic cotton management.** Research trials have determined the Bollgard® transgenic Bt gene technology to be highly effective against tobacco budworms. Bollgard® cottons are also effective against cotton bollworm, but under heavy pressure from this species, insecticide treatment may be needed. **In Bt-cotton, the entire plant should be searched for tobacco budworm and bollworm larvae and injury.** Treatment should not be triggered by the presence of eggs alone, because hatching larvae must first feed on the cotton plant to receive a toxic dose. As in non-Bt cotton, predators and parasites are very important in reducing the number of eggs and larvae, and they complement the control provided by these varieties.

The use of a non-Bt cotton refuge is a requirement for planting Bt cotton and is an important component of resistance management. For additional information on the management of Bt cotton, refer to L-5169, "Bt Cotton Technology in Texas: A Practical View," available from your county Extension office.

## OCCASIONAL PESTS

This section is not intended to provide the detailed information provided for major pests, but should serve to familiarize readers with some of the more common occasional pests and the type of damage they cause. These pests generally are considered to be secondary or induced pests, but can occur without any apparent causal factor.

### Aphids

**Figure 16**. Cotton aphids on underside of cotton leaf.

Two species of aphids, or plant lice, feed on cotton plants: the cotton or melon aphid and the black cowpea aphid. Aphids are small, mobile, soft bodied insects with piercing-sucking mouthparts for feeding on the sap of plants. They are usually found in colonies on the underside of leaves, on stems and in terminals. Aphids can be recognized by their pear-like shape and the pair of cornicles at the end of their abdomen. The cornicles are tube-like structures from which aphids excrete honeydew as they feed. Most adults do not have wings. Immature stages look like small adults. The cowpea aphids are shiny black with white patches on the legs and are common on seedling plants. Cotton aphids range in color from light yellow to dark green to almost black. Cotton aphids are also generally an early-season problem, but can occur at any time in the season. Aphid populations can increase rapidly following applications of certain insecticides, particularly the pyrethroid insecticides.

Heavy prolonged infestations of aphids can cause younger leaves to curl downward, older leaves to turn yellow and shed, and can reduce yield quality and quantity. The honeydew associated with infestations occurring after bolls open can result in stained, sticky cotton of lower quality. This cotton can be difficult to harvest and process at the mill.

Fortunately, natural control by unfavorable weather, predators, parasites and pathogens generally are effective at holding aphid populations below damaging levels, and can be effective at eliminating heavy infestations. Parasites and pathogens associated with aphids can be particularly effective in reducing or eliminating heavy populations, but may require more time to affect these populations than is acceptable.

## Cutworms

The first sign of cutworm damage generally is a reduction in seedling stand, with plants cut off near the soil surface. The caterpillars are often missed because they feed primarily at night and hide in the soil during the day. Cutworms which attack cotton are brownish caterpillars that grow to about one inch long. Control of cutworms is only needed if plant stand density is threatened during the seedling stage. Cutworms are more of a problem in previously fallow fields, and keeping fields as weed-free as possible for 3 weeks prior to planting will minimize cutworm problems.

## Thrips

Thrips are minute (about 1/16 inch), slender-bodied insects. Adults have four long wings fringed with long hairs. Immatures look like adults without wings. Thrips can attack cotton at any point in the season. Problems in seedling cotton in the LRGV generally occur in fields planted near maturing onion fields. As the onions mature and dry down, the thrips move into nearby fields in large numbers and can stunt seedling plants. This situation may justify use of a protective application of a systemic insecticide at planting. Later in the season, thrips are frequently encountered in the blooms and can be extremely difficult to control. Fortunately, thrips generally are not of economic importance late in the season.

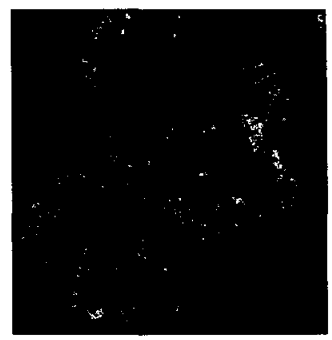


**Figure 17**. Cotton seedlings damaged by thrips.(A. Knutson)

## Spider mites

**Figure 18**. Spidermites and associated leaf speckling damage on underside of cotton leaf.

Spider mites are not insects. They are minute arthropods (about 1/60 inch in length). Like their close relatives, the spiders, spider mites have eight legs. They also produce silk threads which can form a web over entire plants when they reach heavy densities. Spider mites infest the underside of leaves where they feed on plant sap, and they may also infest bracts of squares and bolls. The damage they cause to plant cells first appears as yellowish-brown speckling of leaves. Heavy infestations can cause leaf discoloration (bronzing) and defoliation and cause bracts to desiccate and squares or small bolls to shed. Spider mites generally are more of a problem in dry weather and along field margins, particularly near dusty roads.

## Loopers

Loopers are large caterpillars which get their common name from the characteristic looping action as they crawl. They can be distinguished from most other caterpillars by the presence of only two pairs of abdominal prolegs (plus the anal pair), whereas, most other common caterpillars in cotton will have four pair of abdominal prolegs (plus the anal pair). Their eggs are laid singly, mainly on the lower surfaces of the leaves. The eggs are commonly confused with bollworm/budworm eggs but are more flattened. Loopers are defoliators, with feeding damage characterized by leaf ragging or large holes in the leaves. Loopers are primarily a late-season pest in the LRGV, but can occur throughout the season. Looper larvae are often killed by disease before economic foliage loss occurs. Removal of leaf tissue by loopers just prior to application of defoliants can interfere with crop termination.

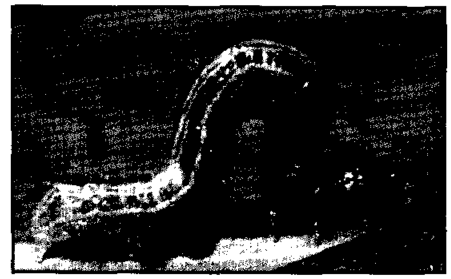


**Figure 19**. Looper larvae on cotton leaf.

## Beet Armyworm

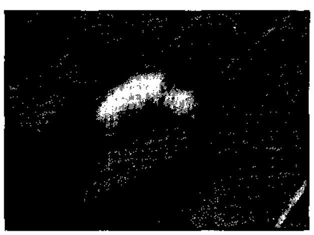


**Figure 20**. BAW egg mass on underside of cotton leaf.

Beet armyworm (BAW) eggs generally are laid on the underside of cotton leaves in masses and are covered by whitish scales from the moths abdomen The early instar larvae feed together on leaves causing characteristic damage symptom often referred to as a "hit". The third instar larvae begin to disperse and become more solitary. Larvae skeletonize leaves rather than chewing large holes in them. During early-season infestations, larvae feed on leaves and terminals. During late-season infestations, larvae will feed on leaves, terminals, squares, blooms and young bolls. Recent history with this pest has shown that severe BAW outbreaks depend on a variety of factors, with the one factor under producer control being the use of early season organophosphate or pyrethroid insecticides. These broad spectrum insecticides eliminate the beneficial arthropods that apparently keep BAW under control, and if other conditions are favorable for the BAW, can lead to large pest population increases.

**Figure 21**. BAW larvae and damage on large cotton square.(A. Knutson)

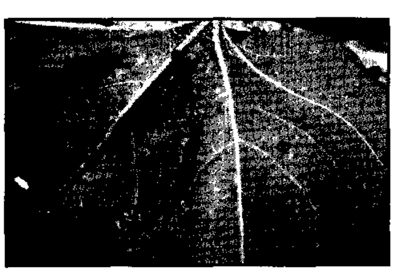


**Figure 22**. Young BAW larvae and feeding damage ("hit").

# BENEFICIAL ORGANISMS

There are a variety of beneficial organisms that play key roles in management of pests in cotton. These organisms can prevent outbreaks of occasional pests and aid producers in management of most key pests. This section is intended to provide aid in identifying some of the more common beneficial organisms that play a role in the cotton ecosystem in the LRGV. For a more complete reference on this subject, refer to Texas Agricultural Extension Service publication no. B-6046, Recognizing the Good Bugs in Cotton: Field Guide to Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton.

The beneficial organisms discussed can be divided into three categories - predators, parasites and pathogens. Predators are organisms that kill and consume more than one prey to complete their development, and they are free-living as immatures and adults. Predators typically are not host-specific and may attack both pest and beneficial prey. Parasites destroy a single prey (host) to complete development, living in or on their host during immature development and are free-living only as adults. Many of the flies and wasps found in cotton fields are parasites of other arthropods in cotton. Most parasites are host-specific, attacking only a single species or a small closely related group of host species. In addition to parasitization of hosts, many parasite adults will kill and feed on hosts. Pathogens are organisms that cause disease. Most insect pathogens are fungi or viruses. Some pathogens are host-specific while others affect large groups of insects (i.e. caterpillars).

## Predators

### Lady beetles

There are several species of lady beetles found in cotton, with most being brightly colored round or oval beetles. Clusters of bright yellow, 1/8-inch long, football-shaped eggs are layed on the plant or on debris on the soil. Larvae are alligator-shaped with blue to black bodies with yellow or orange markings, except for one group which have white fuzzy appearing larvae. Both adults and larvae feed primarily on aphids, but will also prey on eggs and small caterpillars.

**Figure 23**. Lady beetle adults and larvae.

**Figure 24**. Big-eyed bug adult.

### Big-eyed bugs

The big-eyed bugs' name comes from its characteristic broad head and large, bulging eyes. The color varies with species and age, but both adults and nymphs are readily identified by their eyes. Adults are about 1/8 inch long. Both adults and nymphs are predaceous and feed on a variety of cotton pests including moth eggs and small larvae, aphids, whiteflies, and spider mites.

## Green lacewings

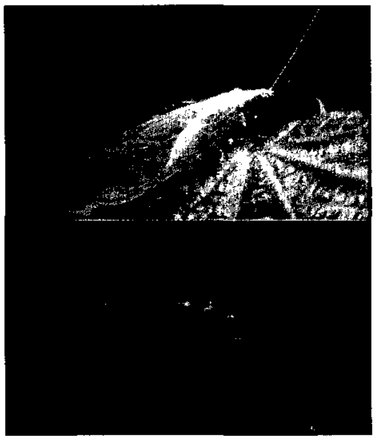


**Figure 25**. Green lacewing adult and larvae.

Adults are delicate, slender green insects (about 3/4-inch long) with long antennae and clear wings laced with veins. Eggs are laid on long slender stalks attached to leaves or stems. The larvae are alligator-shaped with long sickle-shaped mandibles projecting from the head. They pupate inside a spherical, white cocoon, which is often mistaken for a spider egg mass. Larvae of green lacewings prey on aphids, mites, whiteflies, and eggs and small larvae of lepidopterous pests. They will also feed on other beneficial organisms, including other lacewing larvae.

## Minute pirate bug and insidious flower bug

Adults are small (1/8-inch long). They are black with a white X pattern on the back, and have a prominent, forward-projecting beak. Young nymphs are yellow-orange with a distinct orange gland in the abdomen. Later instar nymphs are tan to dark brown. Both adults and nymphs prey on aphids, thrips, mites, whiteflies, and eggs and small larvae of caterpillar pests.

**Figure 26**. Minute pirate bug adult. (W. Sterling)

## Damsel Bugs and Assassin Bugs

**Figure 27**. Damsel bug adult.

Damsel bugs and assassin bugs are predatory bugs. They have piercing-sucking mouthparts and front legs modified for grasping prey (slightly enlarged femora and raptorial). Damsel bugs generally are smaller and less colorful than assassin bugs, but both predators can inflict a painful bite. Damsel bugs feed on a wide variety of prey including moth eggs and small larvae, aphids, fleahoppers, and whiteflies. Assassin bugs feed on mobile prey including caterpillars, aphids and fleahoppers. Assassin bugs are one of the few predators that can prey on large caterpillars and adult boll weevils. Both damsel bugs and assassin bugs will attack other predators.

**Figure 28**. Assassin bug adult.

Figure 29. Syrphid fly larvae and aphids.

## Syrphid flies

Adult syrphid flies most commonly encountered in cotton in the LRGV are small (about 1/4 inch) black flies with yellow markings (striped abdomen). The predaceous larvae are green to brown slug-like maggots. The head is located at the small end of the tapered body. Syrphid fly larvae pierce their prey and suck out body fluids. They are generally found feeding on aphids, but may also consume moth eggs and small larvae.

## Spiders

A wide variety of spiders can be found in cotton, including lynx spiders, crab spiders and jumping spiders. The key predatory spiders in cotton do not catch their prey in a web, but are active, aggressive hunters which chase their prey or hide in wait and ambush their prey. Spiders feed on a variety of pests including fleahoppers, caterpillars and boll weevil adults, and they will occasionally feed on beneficial arthropods as well.

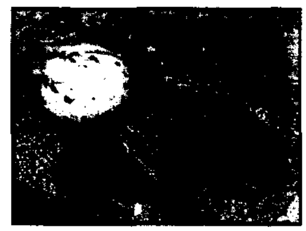


Figure 30. Spider.

**Parasites**

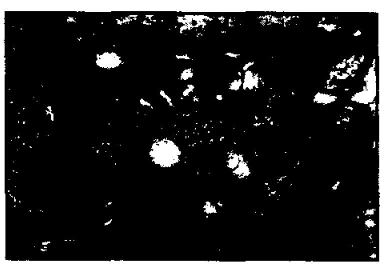


Figure 31. Parasitized aphids (mummies) on cotton.

## Aphid parasites

The most common parasite of aphids in cotton is *Lysiphlebus testaceipes*. The presence of aphid parasites is most readily seen in the development of aphid mummies in the field. Aphid mummies are dead swollen aphids stuck to leaves. The mummies are tan to gold in color and contain a developing parasite or have a circular hole cut in the top from which the adult wasp emerged. This parasite often plays an important role in reducing or eliminating aphid populations.

## Moth egg parasites

*Trichogramma* wasps are extremely small parasites which develop inside the eggs of moths and butterflies, and are the most abundant egg parasites of moths in cotton. They lay their eggs inside of the eggs of a variety of moths including bollworm, budworm and loopers. Parasitized eggs turn black as the wasp develops within. In healthy eggs, the dark head capsule of the developing larvae is seen as a dark spot, but can be distinguished from a parasitized egg which turns a uniform dark color.

Figure 32. Healthy (white) and parasitized (dark) caterpillar eggs.

## Caterpillar parasites

A wide variety of wasps and flies parasitize caterpillars in cotton. Most are internal parasites, which means that the larvae develop inside of the host. Estimation of parasite activity within a field is generally difficult, as parasitized larvae do not always show external signs of parasitism.

## Silverleaf whitefly parasites

A variety of native and introduced parasites attack whiteflies in cotton in the LRGV. The most abundant are *Eretmocerus* and *Encarsia* species. The adult parasites are extremely small and are not likely to be noticed. The most apparent signs of parasite activity are seen by observing older whitefly nymphs and pupal cases. Parasitized whiteflies will turn black or the developing parasite can be seen through the cuticle of the whitefly, depending on the parasite involved. Pupal cases of parasitized whiteflies will have a hole chewed through the top where the adult parasite emerged. Significant whitefly mortality can also occur from host feeding, where the parasite stings the whitefly nymph and feeds on the fluids that flow out.

**Figure 33**. Silverleaf whitefly nymph with parasite exit hole.

Diseases

## Cotton Aphid Fungus

Given enough time, a fungus disease generally breaks out in high density aphid populations. This fungus disease can eliminate infestations in 7 to 10 days. Aphids recently killed by the fungus, *Neozygites fresenii*, are covered with a velvety white to light gray growth. Aphid infestations should be monitored for presence of this disease prior to any pesticide application to evaluate the potential for avoiding the application.

**Figure 34**. Caterpillars showing disease symptoms.(W. Sterling)

## Diseases of Caterpillars

Caterpillars can be attacked by a variety of fungal and viral diseases. Common fungi attacking caterpillars include *Beauveria bassiana, Nomuraea rileyi,* and *Erynia* species. Caterpillars infected by these fungi die within a few days as the fungi grow throughout their bodies. These larvae remain attached to the plant and the fungi grows and sporulates externally, giving the dead larvae a fuzzy appearance. In general, fungal diseases attack a variety of caterpillars, and *Beauveria* will attack other types of insects as well. Common viral diseases of caterpillars are nuclear polyhedrosis viruses (NPV), also called baculoviruses. Larvae killed by NPV's are dark and limp and generally hang from near the top of the plant. The cuticle of these larvae is easily ruptured, releasing a cloudy liquid which contains millions of virus particles. NPV's are generally host specific, attacking only one or a few species.

## THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.


8/97

## THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.


8/97

Table 2. (cont.) Fertilization of Warm Season Perennial Grasses. Note: Spring topdress

| **Forage Crop** | **Topdress in Spring** **$N$-$P_2O_5$-$K_2O$** | **Additional Fertilizer** |
|---|---|---|
| | Lbs/A | |
| Coastal Bermuda (grazing) | 60-50-90 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Coastal Bermuda (1 hay cutting plus grazing) | 100-50-150 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Coastal Bermuda (3 hay cuttings) | 100-100-300* | Topdress with 100 lbs N/A after each hay cutting |
| Coastal Bermuda (4 to 6 hay cuttings | 100-130-400* | Topdress with 100 lbs N/A after each hay cutting |
| Common Bermuda (1 A.U. per 1.5-2.0 A) | 60-30-50 | Topdress with additional 40 lbs N/A as needed. |
| Common Bermuda (1 A.U. per 1.0-1.5 A) | 60-50-80 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Common Bermuda (1 hay cutting plus grazing) | 70-50-90 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Common Bermuda (3 hay cuttings) | 70-60-180 | Topdress with 70 lbs N/A after each hay cutting |
| Common Bermuda (4-6 hay cuttings) | 70-80-250* | Topdress with 70 lbs N/A after each hay cutting |
| Bahia Grass (1 A.U. per 1.5-2.0 A) | 60-30-50 | Topdress with additional 40 lbs N/A as needed |
| Bahia Grass (1 A.U. per 1.0-1.5 A) | 60-50-80 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Bahia (1 hay cutting plus grazing | 70-50-90 | Topdress with 60 lbs N/A after each 4-6 week graze down |
| Bahia (3 hay cuttings | 70-60-180 | Topdress with 70 lbs N/A after hay cutting |
| Bahia (4-6 hay cuttings) | 70-80-250* | Topdress with 70 lbs N/A after each hay cutting |

*At spring growth, apply all of the suggested nitrogen and phosphorus and ½ or more of the suggested potassium. Apply the remaining potassium with topdress nitrogen after the second cutting. Alternatively, all nutrients could be applied proportionally for each cutting.

Table 2. (cont.) Suggested Fertilization For Silage Production.

| CROP (Yield Goal) | | Fertilizer Rate (lbs/A) | | |
|---|---|---|---|---|
| | | N | $P_2O_5$[1] | $K_2O$[2] |
| Silage-Corn | (7-10 T/A) | 100 | 60 | 55 |
| | (11-15 T/A) | 150 | 80 | 100 |
| | (16-20 T/A) | 200[3] | 80 | 120 |
| | (21-25 T/A) | 250[3] | 80 | 120 |
| | (26-30 T/A) | 300[3] | 100 | 160 |
| Silage-Sorghum | (7-10 T/A) | 70 | 60 | 55 |
| | (11-15 T/A) | 130 | 80 | 100 |
| | (16-20 T/A) | 180[3] | 80 | 120 |
| | (21-25 T/A) | 220[3] | 80 | 120 |
| | (26-30 T/A) | 260[3] | 100 | 160 |

[1]If soil test P - 1 ppm; then crop gets 100% $P_2O_5$ recommendation
11 ppm; then crop gets 50% $P_2O_5$ recommendation
≥22 ppm; then crop gets No $P_2O_5$ recommendation

[2]If soil test K - 1 ppm; then crop gets 100% $K_2O$ recommendation
63 ppm; then crop gets 50% $K_2O$ recommendation
≥126 ppm; then crop gets No $K_2O$ recommendation
For other soil test values, take 1 minus ratio of soil test value to value if no fertilizer is recommended (P - 22 or K - 126 ppm).

EXAMPLE: If making phosphorus and potassium recommendations for silage-corn (7-10 T/A) and soil test values are P - 15 and K - 45 ppm; the suggested rates after rounding to the nearest 5 lb. increment would be:

$P_2O_5 = 1 - (15/22) = 0.32 \times 60 = 20$ lbs $P_2O_5$/A
$K_2O = 1 - (45/126) = 0.64 \times 55 = 35$ lbs $K_2O$/A

[3]Split nitrogen: ½ preplant along with all of phosphorus and potassium if recommended. Sidedress remainder of nitrogen prior to initiation of 5th leaf.

# THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.


8/97

# Texas Agricultural Extension Service
The Texas A&M University System

# Irrigated Grain Sorghum Production

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

## TABLE OF CONTENTS



**Prepared in Cooperation with the U.S. Environmental Protection Agency**

The preparation of this report was 60% financed through $443,630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

# IRRIGATED GRAIN SORGHUM PRODUCTION

Charles Stichler and Guy Fipps[1]

## Water Requirements and Growth Stages

Water is the first factor limiting production in any crop. Up to a point, the more water made available to grains, the higher the production with adequate fertility to fully utilize the water. Grain sorghum is a very drought tolerant crop. It has the capacity to survive water stress better than corn. Sorghum develops a diffuse root system that may extend to a depth of 4-6 feet. Table 1 shows the typical amount of water used by a sorghum crop from the various soil depths during a season.

Moisture stress early in the season will limit head size (number of seed per head) and delay maturity, requiring more time to complete the plant's life cycle. If stress occurs later in the season, the seed size is greatly reduced. The number of heads per acre is not effected by moisture stress unless there is not enough to produce a head.

During the seedling stage, only a small amount of moisture in the soil surface is required to establish the crop. More moisture is lost during this stage through evaporation from the soil surface than through the crop canopy. Water conserving practices such as residue management, timely planting for quick establishment, narrow row spacing and weed control will minimize soil moisture losses.

About 30-35 days after emergence, five to six true leaves are visible and the plant begins rapid growth. Nearly half of the total seasonal water will be used during this stage prior to heading. Near the end of this period, daily water use will be near maximum (about 0.35 inches/day/acre).

The most critical period for water availability for a sorghum plant begins about a week before head emergence or the "boot" stage, and continues two weeks past flowering. Sorghum plants require good soil moisture during this period for maximum yields. Adequate soil moisture prior to the "boot" stage will assure the highest potential seed set. The actual seed number and seed size depends on the availability of soil moisture following flowering.

Moisture demand drops rapidly after the grain has reached the "soft-dough" stage. The "soft-dough" stage has occurred when immature seeds squeezed between the thumb-nail and the index finger do not exude a "milk" or white juice. The combined drop in moisture demand, natural drought tolerance in sorghum, and the extensive root system generally make late irrigations unprofitable.

Since water is the first limiting factor to crop production in South Texas, yield goals should be based upon the amount of water available during the season. **Research in**

---

[1]Extension Agronomist and Extension Agricultural Engineer, Texas Agricultural Extension Service, Uvalde and College Station, respectively.

**Texas indicates that a minimum of 10 inches of available water are required for sorghum plants to produce a head. Each additional inch will yield approximately 500 pounds of grain.** In other words, a sorghum crop that receives 20 inches of usable water during the growing season will use 10 inches to produce the head, while the other 10 inches will produce approximately 5,000 pounds of grain.

Maturity selection of hybrids is also important in water management. Table 2 suggests the maturity type based on the amount of expected water available to the crop.

<u>Irrigation/Rainfall Timing</u>

Besides the total amount of available water, the timing of irrigation (or rainfall) is also important. Research done on the Texas High Plains indicates that as the amount of water received by the crop increases, the grain yield/inch of water applied decreases. Results of two years of field studies at the Etter Experiment Station on the High Plains to determine the best combinations for irrigation timing are shown in Table 3. Sixteen irrigation treatments were used. In the first year of the test, 10.5 inches of rain fell in the growing season with 6.1 accumulating late during bloom and grain fill. During the second year of the test, 8.9 inches fell early in the growing season with 6 inches falling prior to and during bloom.

The average yields for the two years shows increasing yields with additional water. The results also show important year to year yield differences with the same irrigation timings when rain fell early or late. Irrigation timing is just as important as the amount of water applied.

More recently, in the first year of experiments conducted at the Uvalde Research and Extension Center, support the Etter findings (Table 4). At Uvalde in 1966, no effective rain fell during the growing season. Results indicate only the effect of irrigations.

Not only is the amount of water applied important, but also the timing relative to the developmental stage of the crop. Based on the results of the experiments at Etter and Uvalde, several important conclusions can be drawn.

- Preplant irrigations alone did not provide sufficient yield.
- One irrigation at any time was equal in yield to two irrigations at heading and dough. **If an irrigation is missed during head initiation (45 DAE), later irrigations will not increase yields substantially.**
- If two in-season irrigations are possible, 45 DAE and heading will produce the highest yields.
- If three in-season irrigations are possible, 30, 45 DAE and heading produce higher yields than 45 DAE, heading and dough.
- Irrigations at the dough stage failed to substantially increase yields.
- Adequate water with 4 irrigations produced the highest yields.

**Table 1.** Total water withdrawn from various soil depths for sorghum growing in a deep, well-watered soil.

| Soil Depth (feet) | Inches of Water Absorbed | Percent of Total |
|---|---|---|
| 0 - 1 | 8.9 | 35 |
| 1 - 2 | 6.6 | 26 |
| 2 - 3 | 4.0 | 16 |
| 3 - 4 | 2.8 | 11 |
| 5 - 6 | 1.3 | 5 |

*USDA/ARS Report No. 29

**Table 2.** Approximate maturity and water use by seasonal types.

| Maturity Range | Days to Bloom | Number of Leaves | Plant Height | Days to Maturity* | Inches of Water |
|---|---|---|---|---|---|
| Early | 55 - 60 | 6 - 9 | 30 - 36 | 90 - 105 | 10 - 15 |
| Medium | 65 - 75 | 9 - 12 | 36 - 45 | 110 - 115 | 15 - 20 |
| Medium Late | 75 - 85 | 12 - 16 | 40 - 50 | 115 - 120 | 20 - 25 |
| Full season or late | 75 - 85 | 14 - 18 | 50 - 60 | 120 - 125 | 25+ |

*Physiological maturity - the point after which there is no increase in seed weight.

**Table 3.** Two year sorghum grain yield responses irrigations; 4 inch irrigations other than preplant ('69 late rains; '72 early rains).

| Preplant | 6-8 Leaf | Mid to Late Boot | Heading/ Flowering | Milk to Dough | 1969 Yield | 1972 Yield | 2 Yr Average |
|---|---|---|---|---|---|---|---|
| X | | | | | 1441 | 2786 | 2113 |
| X | X | | | | 799 | 2842 | 1820 |
| X | | X | | | 4019 | 4249 | 4134 |
| X | | | X | | 3167 | 4908 | 4037 |
| X | | | | X | 1141 | 3268 | 2204 |
| X | X | X | | | 3659 | 3907 | 3783 |
| X | X | | X | | 4181 | 5710 | 4945 |
| X | X | | | X | 1260 | 4201 | 2730 |
| X | | X | X | | 5237 | 5582 | 5409 |
| X | | X | | X | 3677 | 5097 | 4387 |
| X | | | X | X | 3954 | 4727 | 4340 |
| X | X | X | X | | 6396 | 5990 | 6193 |
| X | X | X | | X | 3716 | 5573 | 4644 |
| X | X | | X | X | 4417 | 5932 | 5174 |
| X | | X | X | X | 5956 | 5960 | 5958 |
| X | X | X | X | X | 6800 | 6782 | 6791 |

(Early = 6-8 Leaf; Boot = flag leaf; Heading = flowering to soft dough;
M = milk to soft dough)
*Source: Texas Agricultural Experiment Station - Etter, Texas

**Table 4.** Yield Response of Sorghum to Irrigation at Uvalde.

| Preplant | 30 DAE | 45 DAE | Heading | Dough | Grain Yield per Acre | Heads/ Acre | Grains/ Head | Weight/ Grain |
|---|---|---|---|---|---|---|---|---|
| X | | | | | 1079 | 31914 | 627 | 22.6 |
| X | X | | | | 2811 | 48076 | 1277 | 20.2 |
| X | | X | | | 2890 | 51653 | 1406 | 17.5 |
| X | | | X | | 3016 | 48283 | 1043 | 26.5 |
| X | X | X | | | 3387 | 50277 | 1548 | 19.1 |
| X | | X | X | | 4905 | 53923 | 1560 | 25.9 |
| X | | | X | X | 2704 | 47663 | 883 | 28.9 |
| X | X | X | X | | 5404 | 52006 | 1746 | 26.2 |
| X | | X | X | X | 5116 | 52478 | 1698 | 25.4 |
| X | X | X | X | X | 5773 | 53028 | 1804 | 27 |

DAE = days after emergence 30 DAE = head initiation: 45 DAE = rapid growth; Heading = Boot-Flowering: Dough = Soft dough stage

**Table 5.** The effects of furrow diking and subsoiling on sorghum grain yields.

| Tillage Treatment | 1979 Lbs/A | 1979 % | 1980 Lbs/A | 1980 % | 1981 Lbs/A | 1981 % | Average Yield (Pounds/Acre) | % of Check |
|---|---|---|---|---|---|---|---|---|
| Undiked | 4353 | 100 | 547 | 100 | 1038 | 100 | 1979 | 100 |
| Subsoiled | 4941 | 114 | 580 | 106 | 1116 | 108 | 2212 | 112 |
| Diked | 4865 | 112 | 751 | 138 | 2240 | 216 | 2619 | 132 |
| Subsoiled and Diked | 5136 | 119 | 791 | 145 | 2248 | 217 | 2725 | 138 |

Furrow Diking

If the response of sorghum plants to an inch of irrigation water is an additional 500 pounds/acre of grain, every effort should be made to reduce water runoff. Not only do water conservation practices such as furrow diking reduce the chances of erosion and nutrient loss, they also increases grain yields. Three years of research on the Texas Rolling Plains demonstrate the potential for furrow diking to increase sorghum yields (Table 5).

The greatest impact from furrow diking was observed in the dry years (1980, 1981). Six years of studies in Uvalde on dryland grain sorghum production produced up to 72% higher yields in dry years when fields were diked. Table 6 shows the effects of various tillage systems on the average production between 1984 and 1990 which included wet and dry years.

## Growth and Development of the Plant

Seedling Development

The seedling development stage begins at germination and ends 30-35 days after emergence when plants have five to six mature (fully expanded) leaves. Emergence and early plant growth are highly dependent upon growing conditions. Plant growth requires energy, but it takes time to produce carbohydrates with a few small leaves which are subject to destruction by wind, insects and pests. As plants slowly develop their root systems and absorb water and nutrients, leaf tissue expands and produces carbohydrate energy for future growth. During this period of development, water and nutrient uptake are low and only about 25% of the total crop nutrient demand will be absorbed.

Rapid Growth

In the rapid growth stage, growing point differentiation occurs and the panicle or head begins to develop. This stage continues through head exertion. Plants are especially sensitive to any type of stress during this period such as temperature extremes, nutrient deficiencies or water deficits or excesses, any of which may reduce potential seed numbers. Some herbicides (e.g., phenoxy or atrazine) applied at this time may cause florets to abort resulting in a "blasted" head. The rate of water and nutrient uptake increases rapidly during this period with about 70% of the nitrogen, 60% of the phosphorus and 80% of the potassium being absorbed into the plant.

Plants use a portion of these nutrients for growth while the remainder is stored in the leaves and stalks for later use. By the time the "flag leaf" is visible in the whorl, 80% of the total leaf area is capturing sunlight and converting it into energy. This stage is the most critical stage of plant development and the period during which growing conditions ultimately determine yield.

Reproduction

The final growth stage begins with booting or head expertion and ends with mature grain. Water stress during this period reduces the manufacturing of carbohydrates and yield. Water usage peaks shortly after flowering at 0.30 to 0.35 inches of water per day. The remaining portion of nutrients is absorbed during this high water use period. (R. L. Vanderlop describes in detail nine stages in *How a Sorghum Plant Develops,* Bulletin

No. S-3, Kansas State University.)

**Fertility Needs of Sorghum**

Like other grains, seed production in sorghum is a one time event and all root, leaf and stem development are directed toward completion of the reproductive cycle. Since both the number and weight of seed determine yield, it is important to understand the plant processes that influence seed development. Plant growth in each stage of development is dependent on the previous stage. Stress in any stage of development will reduce yield potential.

Many producers falsely believe that sorghum is "tough" and requires little management. Although sorghum can survive and produce seed under adverse conditions, yields can be greatly reduced by environmental stress and poor management. Like any other crop, sorghum responds to optimum growing conditions and good management.

The fertility needs of sorghum must be met in order to meet the yield goals relative to the amount of moisture available during the growing season. Table 7 indicates the approximate level of nutrients needed to produce a grain yield of 5,600 pounds per acre (100 bu/ac).

Table 8 shows the amount of nitrogen, phosphorus and potassium absorbed by grain sorghum plants during various stages of development in the process of producing 7,500 pounds of 14% moisture grain per acre. Nutrient distribution in dry matter between grain and stover is presented in Table 9. Note that very little phosphorus and potassium are present in the sorghum grain, relative to the amount of nitrogen. Conversely, a substantial amount of potassium is contained in sorghum stover relative to nitrogen and phosphorus. If stover is removed repeatedly, soil phosphorus and potassium levels may be depleted.

Nitrogen

The standard nitrogen (N) recommendation for grain sorghum in Texas is 2 pounds per acre of elemental N for each 100 pounds per acre of grain production expected. Thus a 5,000-pound grain yield would need about 100 pounds of elemental nitrogen per acre. Nitrogen is by far the most important nutrient for sorghum to maximize production. Nitrogen is normally used by plants for chlorophyll and protein production, which in turn are used in formation of new plant cells. The seed also store N to enable early growth after germination. Fifty-six percent of the N absorbed by sorghum plants may be found in the seed at harvest (Table 9). For maximum yields relative to the available water, N should not be lacking or grain development will be reduced.

Side-dress N applications should be made by 20 days after emergence. Later applications may excessively prune feeder roots; but more importantly, developmental potential of the grain head is determined between 30-40 days after emergence. Nitrogen stress during this period will greatly influence yield. Under center pivot irrigation, N fertilizer may be applied several times during the early part of the growing season.

Because N is relatively mobile in the soil, fertilizer placement is not as critical for N as it is most for other nutrients. Nonetheless, N must be absorbed into the plant before it is supportive of plant growth and grain

**Table 6.** Effect of furrow diking on dryland sorghum production.

| Treatment | Average Yield | Percent of Bedded & no dikes |
|---|---|---|
| Bedded and no dikes | 1747 a | |
| Flat (no beds formed) | 1821 a | 104 |
| Bedded and diked during the growing season | 1826 a | 105 |
| Bedded and diked during the fallow season | 2128 b | 122 |
| Bedded and diked continuously | 2321 b | 133 |

**Table 7.** Approximate nutrient content of a 5,600 pounds/acre sorghum crop.

| Plant Nutrient | Pounds in Grain | Pounds in Stover |
|---|---|---|
| Nitrogen (N) | 84 | 95 |
| Phosphorus ($P_20_5$) | 42 | 20 |
| Potassium ($K_20$) | 22 | 107 |
| Sulfur (S) | 8 | 13 |
| Magnesium (Mg) | 7 | 10 |
| Calcium (Ca) | 1.4 | 19 |
| Copper (Cu) | .01 | .02 |
| Manganese (Mn) | .06 | .11 |
| Zinc (Zn) | .07 | .14 |

*Source: Kansas State University

**Table 8.** Approximate amounts of nutrients absorbed by sorghum plants yielding 7,500 pounds of grain per acre during various growth stages.

| Growth Stage | Days after Planting | Nitrogen N (lb/A) | % | Phosphorus $P_2O_5$ (lb/A) | % | Potassium $K_2O$ (lb/A) | % |
|---|---|---|---|---|---|---|---|
| Seedling | 0 - 20 | 9 | 5 | 2 | 3 | 18 | 7 |
| Rapid Growth | 21 - 40 | 61 | 33 | 18 | 3 | 103 | 40 |
| Early Bloom | 41 - 60 | 60 | 32 | 28 | 33 | 85 | 33 |
| Grain Fill | 61 - 85 | 27 | 15 | 21 | 26 | 39 | 15 |
| Maturity | 86 - 95 | 28 | 15 | 11 | 14 | 13 | 5 |
| TOTALS | Harvest | 185 | | 80 | | 285 | |

**Table 9.** Approximate nutrient distribution between grain and stover for a 7,500 lb/A sorghum crop.

| Plant Part | Dry Matter distribution % | Nitrogen (lbs/A) | Nitrogen % of Total | Phosphorus (lbs/A) | Phosphorus % of Total | Potassium (lbs/A) | Potassium % of Total |
|---|---|---|---|---|---|---|---|
| Grain | 56 | 84 | 47 | 42 | 68 | 22 | 20 |
| Stover | 44 | 95 | 53 | 20 | 32 | 230 | 80 |

*Source: Kansas State University

production. Nitrate-nitrogen ($NO^-_3$, the form most available to plants) dissolves in soil water, but is negatively charged and thus not attracted to negatively-charged clay and organic matter particles . Hence, nitrate-nitrogen will move with water and can be readily brought into contact with crop roots for quick absorption. Ammonium-nitrogen ($NH^+_4$, also available to plants) is positively charged and is held by negatively-charged clay and organic matter particles in the soil until it is converted by soil bacterial action into the nitrate form.

The conversion of N from the ammonium form to the nitrate form in the soil is referredto as "nitrification", and is be most likely to occur when fields are arable. When fields are "water-logged", nitrate can be converted to nitrogen gas (referred to as "denitrification"), and lost from the soil by volatilization. Whether fertilizer N is applied as liquid or dry, ammonia, urea, ammonium sulfate, or N-32 should be incorporated into the soil as soon as possible to reduce potential loss of N to the atmosphere, especially where soil pH is above 7.

Phosphorus

Phosphorus (P) is the most controversial nutrient. Different soil testing laboratories utilize different chemical extractants to estimate "available P". As a result, there may be large differences between soil test values for the same soil sample obtained from different laboratories. In addition, fertilizer recommendations from different laboratories may also vary considerably.

In most cases, soil P levels are sufficient to meet early season needs of grain sorghum plants. However, grain sorghum seed are small and contain only enough P to nourish young seedlings until emergence. If young seedlings develop under favorable conditions, P-deficiency symptoms often do not occur. Also, if growing conditions are unfavorable (i.e., cool and/or wet), seedlings may show temporary P-deficiency symptoms. In years where the planting environment is unfavorable for rapid growth and development, banding P fertilizer at low rates in the seed row may be beneficial. Also banding P two to three inches below and two to three inches to the side of the expected seed placement may be beneficial.

One key point to remember is that P is less available in cold soils. Most growers plant as early as possible to reduce sorghum midge damage and to minimize the effects of hot, stressful weather normally experienced later in the season. By doing so, sorghum seedlings often must establish and grow in much cooler soils than if planted later in the spring.

Since soil P is relatively immobile, or "fixed" in soils, placement in a concentrated form is particularly important in soils testing low to medium. By banding P near the seed, 2-4 inches below and 2-4 inches to the side, developing roots contact the fertilizer shortly after emergence. Placing P fertilizer in direct contact with sorghum seed at planting may cause emergence problems due to the salt effects caused by nitrogen in the fertilizer material. Research has shown that plants obtain a higher proportion of the needed P from soil reserves. Only about 30 percent of applied P is used by the crop following fertilization, even though it may have been banded. Once soils are warm, some of the "reserve" P becomes available for plant use. The rate at which fertilizer P is converted to soil or "reserve" P depends upon several factors, but most important is the fertilizer P-to-soil contact. Confining P fertilizer to a band reduces fertilizer-to-soil contact and slows the rate of conversion, compared to mixing the same amount throughout the soil as with broadcast applications.

Phosphorus can also be applied as a "pop-up" fertilizer, sprayed in the seed furrow at planting. Corn and sorghum usually respond better than cotton to "pop-ups". However, when using a product like 10-34-0 or 11-53-0 as a "pop-up", it is important not to exceed the equivalent of 5 pounds of elemental N per acre in the seed furrow, or salt injury from the N is likely to occur. Under irrigated or high rainfall conditions, up to 10 pounds of N/acre may be applied without injury. A rain following planting will dilute the nitrogen and also lessen the chance of injury. High P to low N ratio specialty fertilizers, such as 4-29-2 or similar products, lend themselves to "pop-up" applications with minimal injury risk.

Potassium

Potassium (K) is needed in all plant parts for maintenance of water balance, disease resistance and stalk strength. However, as indicated in Table 5, very little K is removed from the field if only grain is harvested. If the stover is harvested for forage, then a much larger amount of potassium is removed. Most high pH soils in Texas are inherently high in potassium. Soil test levels should be monitored over years to look for any trends of reduced K.

Other Nutrients

Two of the other most important nutrients for grain sorghum production in Texas are zinc and iron. Where soil phosphorus levels are "high" or "very high" and zinc levels are "low" to "medium", application of additional phosphorus may induce a zinc deficiency. If soil test results indicate a possible zinc deficiency, zinc fertilizer should be broadcast and incorporated preplant or banded at planting. Foliar applications of zinc should be used as a salvage measure since this will only prevent symptoms on new growth.

If iron chlorosis has been observed during previous years in a field, iron fertilizer materials should be applied to the foliage through multiple sprayings early in the season. Information on specific application rates of micro nutrients can be found in the following Texas Agricultural Extension Service manuscripts: *Correcting Iron and Zinc Deficiencies in Corn and Grain Sorghum* (W. Gass, Soil and Crop Science Dept.) and *Correcting Iron Deficiencies n Grain Sorghum,* L-5155.

## Irrigation Scheduling Based on Potential Evapotranspiration (PET)

Evapotranspiration (**ET**) is a measurement of the total amount of water needed to grow plants and crops. This term comes from the words *evaporation* (i.e., evaporation of water from the soil) and *transpiration* (i.e., transpiration of water by plants). Different plants have different water requirements, so they have different ET rates.

**Table 10.** Sorghum Crop Coefficients.

| **Growth State**[1] | $K_c$ | **Days After Planting**[2] |
|---|---|---|
| Seeding | 0.40 | 3 - 4 |
| Emerg | 0.40 | 5 - 8 |
| 3-leaf | 0.55 | 19 - 24 |
| 4-leaf | 0.60 | 28 - 33 |
| 5-leaf | 0.70 | 32 - 37 |
| GPD | 0.80 | 35 - 40 |
| Flag | 0.95 | 52 - 58 |
| Boot | 1.10 | 57 - 61 |
| Heading | 1.10 | 60 - 65 |
| Flower | 1.00 | 68 - 75 |
| S Dough | 0.95 | 85 - 95 |
| H Dough | 0.90 | 95 - 100 |
| Blk lyr | 0.85 | 110 - 120 |
| Harvest | 0.00 | 125 - 140 |

[1]Sorghum will bloom at different times depending on locating, planting date, and maturity of the variety.
[2]The Days After Planting are for a medium-early to medium-late variety.

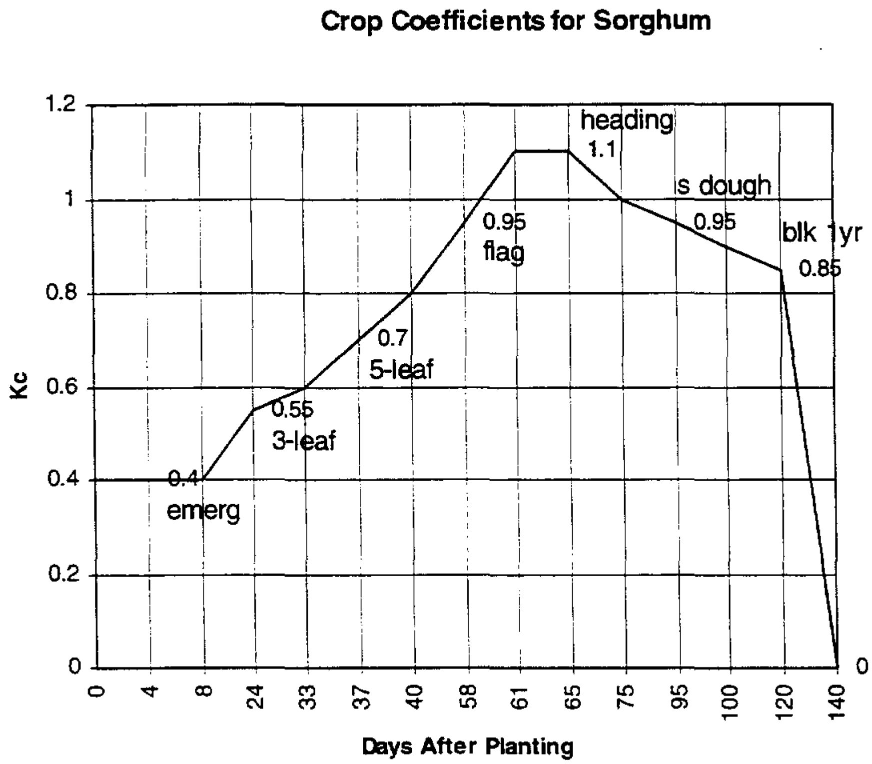



**FIGURE 1.** Crop Coefficient Curve for Sorghum.

**Table 11.** Typical overall on-farm efficiencies for various types of irrigation systems.

| System | Overall Efficiency |
|---|---|
| Surface | .50 - .80 |
| common | .50 |
| land leveling and water volume per row meeting design standards | .70 - .80 |
| surge | .60 - .90[1] |
| Sprinkler | .55 - .75[3] |
| Center Pivot | .55 - .90[3] |
| LEPA | .90 - .95 |
| Drip/Trickle | .80 - .90[2] |

[1]Surge has been found to increase efficiencies 8 to 28% over non-surge furrow systems.
[2]Trickle systems are typically designed at 80 to 90% efficiency.
[3]Higher efficiencies are for low wind conditions.

Since there are thousands of cultivated plants, we have tried to simplified matters by establishing a standard ET rate for general reference and use. The standard is coefficient (Kc). Crop coefficients depend on the type of crop and its stage of growth. The North High Plains crop coefficients for sorghum are listed by stage of growth in Table 10 and illustrated in Figure 1. Please note that these dates are provided as a general guide only, as crop growth rate is affected by many factors including variety, current weather, soil moisture conditions, etc.

How to Use PET

To calculate the water requirements of a crop, we multiply the PET times the crop coefficient using the following equation:

**PET** x **Kc** = **crop water requirements** (equation 1)

where:

**PET** is the sum of daily PET over the time period of interest, such as the 3-day total, the weekly total, etc.

**Kc** is the crop coefficient corresponding to the current stage of crop growth.

Example 1: the 5-day PET total is 1.32 inches. My sorghum is in the "heading" growth stage. What are the water requirements? (Note: from Table 10, the "heading" crop coefficient is 1.10)

1.32 inches x 1.10 = 1.45 inches

Thus, I need to apply 1.45 inches to replace the water used by the sorghum in the last 5 days.

Adjusting for Irrigation System Efficiency

It may be necessary to increase the amount of irrigation water in order to compensate for poor irrigation system efficiency. Table 11 gives the typical ranges of on-farm irrigation systems. To adjust for irrigation system efficiency, use the following equation:

**PET** x **Kc** ÷ **Eff** = **irrigation water requirements** (equation 2)

where:

**Eff** is the overall efficiency of the irrigation system.

Example 2. I am irrigating with a low-pressure center pivot. I estimate that my overall system efficiency is 85%. What are my irrigation water requirements for the sorghum in example 1?

1.32 inches x 1.10 ÷ 0.85 = 1.71 inches.

Adjusting for Rainfall and Soil Moisture

Rainfall reduces the amount of water we must supply by irrigation to meet plant water requirements. However, not all rainfall becomes available for use by plants and crops. Depending on such factors as soil type, duration and intensity of rainfall, soil moisture levels, etc., a portion of the rainfall will be lost to runoff and deep percolation (water moving below the root zone). In irrigation scheduling, the term "*effective rainfall*" refers to that portion of rainfall which infiltrates and is stored in the root zone. Effective rainfall must be estimated for each field and rainfall event. The irrigation requirement determined with equations (1) or (2) should be reduced by the amount of effective rainfall.

Alternatively, soil moisture monitoring devices can be use to determine soil moisture levels and to determine when irrigations should be re-started following rains. The following two publications by the Texas Agricultural Extension Service discuss this in detail: *Soil Moisture Management* B-1670, and *Soil Moisture Monitoring*-1610.

Where to Find PET Information

For persons with Internet access, PET and weather information is provided for about 12 locations in Central and South Texas, including 3 locations in the Lower Rio ande Valley, on the Texas PET Web Site. The address is:

http://www.agen.tamu.edu/pet

Persons without Internet access should contact their water district or County Extension Agent to see if this information is being provided locally in another way.

**Irrigation Volumes and Soil Types**

The amount or depth of water that is applied at each irrigation depends greatly on soil type. This is because soils vary in their ability to hold or store water. For example, clays can hold about 2 inches of water per foot, while sands hold less than an inch. This is referred to on the "available holding capacity". Table 12 provides recommended irrigation depths in terms of inches of water per foot of root zone. Note from Table 1, the majority of water is withdrawn from the top two feet of the root zone.

**Maximizing Irrigation Water Use Efficiency**

"Irrigation return flow" is that portion of water which returns to its source after being used to irrigate crops. A good example is found in the Texas rice industry, where water is usually diverted from a river, used to flood the field and then released back into the river before harvest. With increasing environmental concern, the term "irrigation return flow" has been extended to include irrigation water that makes its way to any body of water after its use on a crop.

There are many examples of this broader definition in Texas. Tailwater from furrow irrigation and runoff caused by excessive irrigation or poor system design can make its way into small creeks and draws which eventually lead to our major rivers and reservoirs. Water from irrigated land that is artificially drained must go somewhere, often into the same river it was taken from or to major drainage outlets which flow into coastal bays.

Irrigation return flow is becoming an important issue because of its potential to be a nonpoint source of pollution. However, this is not the only reason irrigators should use return flow management practices. Excessive runoff is a symptom of poor irrigation system design or poor management of irrigation water. It is also water wasted Wasting water not only has immediate financial ramifications, but also threatens the long-term availability of water for irrigation. Sound management practices can reduce irrigation return flow while ensuring the most efficient use of our water resources.

The major concern is the direct runoff which may occur from irrigated land. Many of the fertilizer nutrients and chemicals used in agriculture, as well as soluble salts contained in the irrigation water, are easily adsorbed onto soil particles. When runoff occurs, soil particles containing these adsorbed pollutants are picked up and transported out of the field. Eroded sediments constitute the major potential for pollution from surface return flows. In addition, soluble chemicals are dissolved by runoff and carried with the water as it flows over the soil.

**Preventing Return Flow**

There are three basic approaches to eliminating pollutants in surface return flows:

- eliminating or reducing surface runoff;
- eliminating or reducing soil loss; and
- removing pollutants from irrigation return flow.

The first two approaches are achieved by properly designing, operating and managing irrigation systems. Following the directions on the pesticide label will usually solve any problems associated with chemigation (the application of agricultural chemicals through the irrigation system). The third approach involves the use of grass buffer strips, artificial wetlands, settling basins and ponds, and similar structures to remove pollutant bearing sediments. Treating return flow is more costly and troublesome than preventing it.

Practices which may be used to reduce subsurface return flow include:

1. proper leaching; and
2. Impervious conveyance systems.

**Irrigation System Design**

Sprinkler and Drip Irrigation

Emitters and nozzles should be sized so that the irrigation application rate does not exceed the water intake rate of the soil. For center pivot systems, conservation practices such as furrow diking and planting in a circle may be needed.

Furrow Irrigation

Furrow irrigation is used on more than half the total irrigated land in Texas. Proper system design improves the distribution and uniformity of applied water, reduces water use and produces higher yields. The U.S. Natural Resources Soil Conservation Service (NRCS) has developed furrow system design standards and guidelines, based on soil type, for most areas of the state. The important factors are proper slopes, proper stream size and proper furrow run length. Furrow run length and stream size both depend on the slope, and should be selected to minimize tailwater while providing a good distribution of water in the entire furrow.

**Proper slopes** - Excessive slopes may cause severe erosion that transports sediment and adsorbed pollutants. Slope recommendations for reducing return flows vary from location to location because of differences in soils and rainfall conditions. Generally, furrow grade should not exceed 0.8 percent. In areas of intense rainfall, furrow grades may need to be 0.5 percent or less. Proper slopes sometimes can be obtained by changing the direction of the furrows. On smooth, uniformly sloping fields, furrows may be run across the slope of the field as long as they are deep enough and the soil stable enough so that irrigation water or rainfall runoff does not break over one furrow to another. In other situations, land leveling may be the only method of obtaining proper slopes.

**Proper stream size** - Proper stream size may prevent potential erosion. For graded furrows, the stream size should be kept as small as possible to provide reasonable efficiency while minimizing the soil loss. From an erosion standpoint, the maximum stream size in gallons per minute (not to exceed 50 gpm) can be calculated as:

$$\text{stream (gpm)} = \frac{10}{\text{percent furrow slope}}$$

**Cut back irrigation and surge** - An effective practice for reducing tailwater is the use of cut back irrigation. A greater initial flow is normally required to push the water to the end of the furrow. Once the water has reached the end of the furrow, the stream size is reduced or cut back so that the flow correspond more closely to the intake rate of the soil. A less labor intensive practice is to use automatic surge valves to release water into the furrow in a series of on-off cycles; this can reduce tailwater and improve distribution efficiencies. Surge irrigation appears to work because of the natural surface sealing properties of many soils during wetting and drying cycles. Properly managed surge irrigation has been found to increase efficiencies from 6 to 30 percent over nonsurge furrow irrigation, depending on soil type.

Transporting irrigation water through pipelines has proven to be the most trouble free and cost effective method. Gated pipe in furrow irrigation can reduce water and labor costs 35 to 50 percent over siphon tubes and unlined canals. As with other return flow management practices, reducing seepage losses not only helps prevent pollution problems, but has direct economic benefits.

**Irrigation Water Management**

Proper irrigation water management means timing and regulating water applications in a way that will satisfy the needs of a crop and efficiently distribute the water without applying excessive amounts of water or causing erosion, runoff or percolatiion losses. Good irrigation water management can reduce moisture extremes and associated plant disease problems, which in turn may reduce the need for pesticides. The irrigator should have a good understanding of the factors influencing proper irrigation scheduling and water management (Table 13). The timing of irrigation and the total amount applied per irrigation should be based on both the crop's water use and the moisture content of the soil, as well as on expected rainfall and any additional amounts needed for leaching to maintain a specific salt balance. Monitoring soil moisture with gypsum blocks or tensiometers can help take the guess work out of irrigation scheduling.

**Table 12.** Approximate Water Holding Capacity of soils in inches of water per foot of soil and recommended depth of irrigation in inches of water per foot of root zone and total inches.

| Soil Texture | Available Moisture (in/ft) | Water to be replaced at each irrigation* per ft (in/ft) | 2-ft root zone (in) | 4-ft root zone (in) |
|---|---|---|---|---|
| Sands | 0.8 - 1.0 | 0.5 - 0.8 | 1.3 | 2.8 |
| Sandy Loams | 1.3 - 1.5 | 0.8 - 1.2 | 2 | 4 |
| Loams | 1.6 - 1.8 | 1.1 - 1.3 | 2.4 | 4.8 |
| Silt Loams | 1.7 - 1.9 | 1.2 - 1.5 | 2.8 | 5.4 |
| Clay Loams | 1.9 - 2.1 | 1.3 - 1.7 | 3.0 | 6 |
| Clays | 2.0 - 2.2 | 1.4 - 1.8 | 3.2 | 6.4 |

*based on application of irrigation when 50 to 60 percent of the available water in the root zone has been depleted assuming 75 percent overall irrigation efficiency.

**Table 13.** Factors important in proper irrigation water management and irrigation scheduling.

| Soil Factors | Crop Factors |
|---|---|
| Soil water holding capacity | Rooting depth |
| Soil intake rate | Water depletion tolerance |
| Current moisture deficit | Peak consumptive use |
| Depth of soil profile | Variations in consumptive use during each growth stage |

# THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.


8/97

# THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.



Cooperative Extension work in agriculture and family and consumer sciences, The Texas A&M University System, and the United States Department of Agriculture cooperative. Distributed in furtherance of the acts of Congress of May 8, 1914, as amended June 30, 1914.
8/97

Texas Agricultural Extension Service
The Texas A&M University System

# Calibrating
# Pesticide Application Ground Equipment

## Calibration Guide and Software

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

**PREPARED IN COOPERATION WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY**

The preparation of this report was 60% financed through $443,630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

# PESTICIDE APPLICATION GROUND EQUIPMENT CALIBRATION GUIDE

*Bryan W. Shaw and Guy Fipps*[1]

Precise application of a specific rate of pesticides is an important factor in efficient, economical pest control. This guide includes suggested methods for equipment calibration in a convenient, easy-to-use form. Calibrate equipment carefully and accurately as a part of your pesticide application program.

## Application Program Checklist

• Maintain a complete record of the operation.

• Inform those working with the pesticide and others in the area of the precautions necessary in handling the chemical.

• Begin with clean equipment. Residues in the spray rig can cause serious problems. To clean the rig, use either a strong household detergent or a commercial decontaminate formulation (most contain a combination of soda ash, detergent, and alkaline chlorine). Rinse thoroughly with clean water. Remove nozzles to clean screens and tips. Dispose of rinse water safely. Clean and lubricate pump.

*IMPORTANT: Equipment used to apply certain pesticides should not be used to apply others. EXAMPLE: Do not use equipment used to apply 2,4-D, MCPA, 2,4-DP, MCPP, and 2,4-DB for any other purpose because of difficulty in removing all traces of the pesticide.*

• Check all hoses. Hoses in good condition save time and eliminate possible spray mixture losses.

• Use screens upstream of the pump and each nozzle. Check screens *often* to avoid clogged nozzles.

• Use recommended nozzle types and attach nozzles firmly, using the correct height and angle to ensure proper application.

• Calibrate the sprayer and check each nozzle for output uniformity. Replace any nozzle that varies more than 10% from the average flow rate. For application of some chemicals (e.g., certain potent sulfonyl urea herbicides), nozzles should be replaced if they deviate more than 5% from the average flow rate.

Nozzle pressure should follow nozzle manufacturer's recommendation for each application type. Operating near the lower recommended pressure will produce larger droplets and minimize drift potential. Recommended nozzle pressure ranges from 10 to 60 psi for weed control. For insect control, pressure between 50 and 60 psi is typically recommended. Disease control typically requires that a pressure of 100 psi be maintained. Select nozzles which will deliver the calculated volume at the recommended pressure. If the sprayer is already equipped and the nozzles will not deliver the gallons per acre in the desired time, changing speed, gallons per acre (GPA) or nozzles will allow a desired nozzle pressure.

[1] Extension Agricultural Engineers, Department of Agricultural Engineering, Texas A&M University System, College Station, Texas 77843-2117

## Calibration of Ground Sprayers

*Method I*

Step 1:
Fill the tank with water to a predetermined level.

Step 2:
Drive in a straight line for 660 feet, operating at the same pressure and tractor speed planned for field use. Record the tractor throttle and gear settings.

Step 3:
Stop spraying at the 660 foot mark and measure the gallons of water needed to refill the tank.

Step 4:
Measure the width of actual area sprayed. For band applications, this equals the sum of the width of all bands.

Calculate as follows:

$$\frac{gallons\ used \times 66}{width\ of\ sprayed\ area\ in\ feet} = gallons\ per\ acre$$

EXAMPLE:
When 7 gallons of water are required to refill tank to predetermined level for a boom sprayer (14 feet wide) after spraying a 660 feet long swath, the calculations are as follows:

$$\frac{7\ gallons \times 66}{14\ feet} = 33\ gallons\ per\ acre$$

After calibrating the sprayer, add the correct amount of pesticide to the sprayer tank in the correct amount of carrier for the area to be sprayed. Tables 4-9 provide forms to assist with mixing calculations.

Recalibrate the sprayer after each 10 hours of operation or anytime there is a change in the formulation of pesticide used. Recalibrate more often when using wettable powders than when liquid formulations are used. Wettable powders cause wear of pumps and nozzles made of soft metals.

*Method II* (See Tables 1-3 for calibration forms)

Step 1:
With the sprayer and other attachments (planters, applicators, etc.) mounted on the tractor, you are ready to calibrate.

Step 2:
In the field, with all attachments in operation, determine the speed you wish to travel. For tractors with accurate speed sensors, skip to step "5." Speed indicators that do not directly measure ground speed may indicate speed with as much as 30% error due to variation in tire slip, tire size, etc. If in doubt, perform steps "3" and "4."

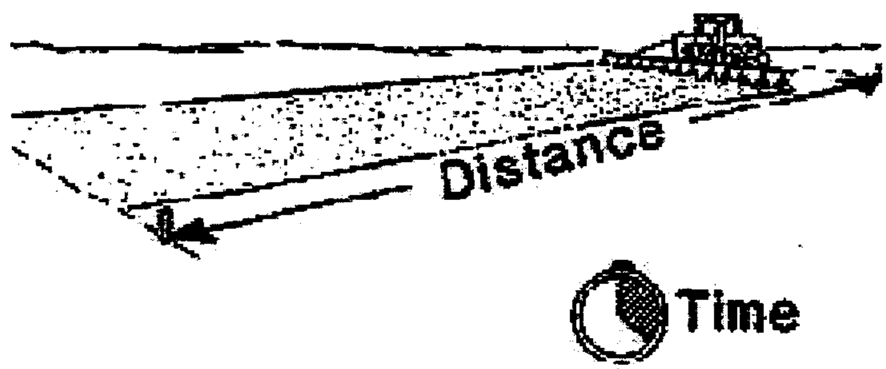
Step 3:

Measure and mark off a course. A longer course gives more accurate speed determination. A course 300 feet long is adequate. Measure in seconds how long it takes to travel the distance. *Mark throttle and gear setting. NOTE: A tractor travels slower in a soft field than on hard ground under the same settings.*

Step 4:

Substitute the number of seconds to travel the course and the length of the course in the following formula to determine MPH.

$$MPH = \frac{feet\ traveled\ x\ 60}{seconds\ traveled\ x\ 88}$$




EXAMPLE:

If it requires 51 seconds to cross a course 300 feet long, the speed is calculated as follows:

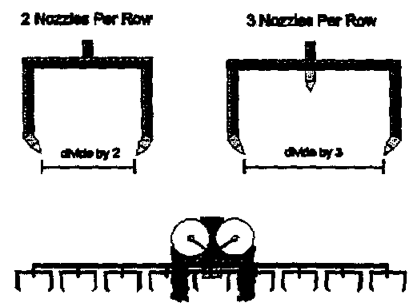
$$\frac{300\ x\ 60}{51\ x\ 88} = 4\ MPH$$

If the desired speed is selected, the seconds to travel the course can be determined as follows:

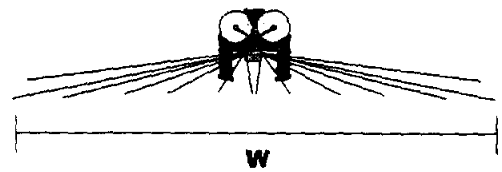
$$seconds\ traveled = \frac{feet\ traveled \times 60}{MPH \times 88}$$

Step 5:

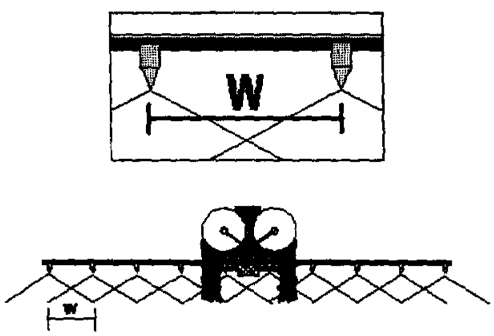
Determine spray delivery from each nozzle in gallons per minute (GPM) for the desired speed, effective spray width, and gallons per acre (GPA). Effective spray width is determined as follows: nozzle spacing for boom spraying, band width for band spraying, spray swath for broadcast boomless spraying, width of band divided by number of nozzles for multi-nozzle band spraying, measured in inches.



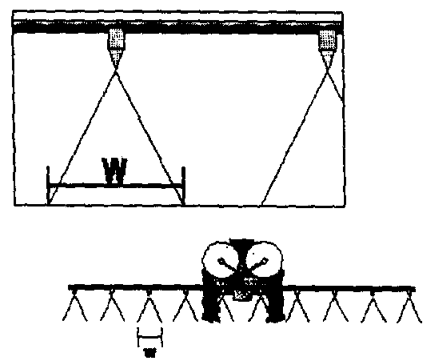

**Multi-Nozzle**




**Broadcast boomless**




**Boom**




**Band**

Calculate the nozzle delivery rate with the following formula

$$GPM\ per\ nozzle = \frac{GPA \times MPH \times W}{5940\ (constant)}$$

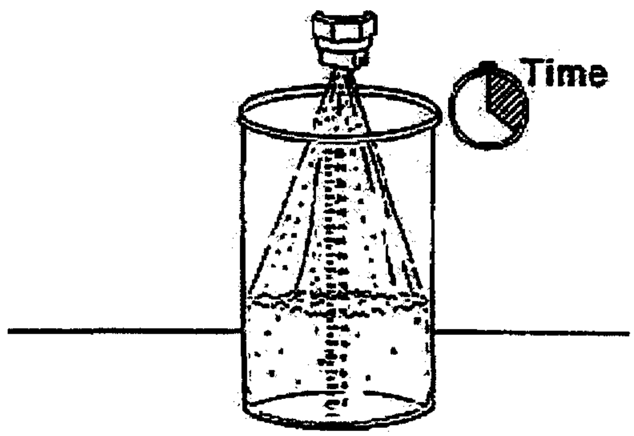
*GPA = gallons per acre on the area treated*
*W = effective spray width in INCHES*

Nozzle pressure should follow nozzle manufacturer's recommendation for each application type. Operating near the lower recommended pressure will produce larger droplets and minimize drift potential. Recommended nozzle pressure ranges from 10 to 60 psi for weed control. For insect control, pressure between 50 and 60 psi is typically recommended. Disease control typically requires that a pressure of 100 psi be maintained. Select nozzles which will deliver the calculated volume at the recommended pressure. If the sprayer is already equipped and the nozzle will not deliver the gallons per acre in the desired time, a change in speed, GPA or change to a larger nozzle will allow a desired nozzle pressure.

Step 6:

With tractor out of gear and engine running at the throttle setting selected, adjust the pressure regulator so that each nozzle delivers the calculated flow rate.

The flow rate can be measured with a tip tester that indicates flow rate in gallons per minute or by measuring the time required to collect one quart from the nozzles.




The number of seconds to collect a quart of spray mixture, or 32 fluid ounces, is determined by the following formula.

Step 7:

$$sec\ /qt\ /nozzle = \frac{15}{GPM\ per\ nozzle}$$

Adjust height and direction of nozzles to give the desired spray pattern overlap or band width as recommended by the nozzle manufacturer.

Step 8:

You must recalibrate if you change speed or pressure. Nozzles wear and sprayers should be recalibrated after each 10 hours of operation or anytime there is a change in the formulation of pesticide used.

Step 9:

After calibrating the sprayer, add the correct amount of pesticide to the sprayer tank in the correct amount of carrier for the area to be sprayed. Tables 4-9 provide forms to assist with mixing calculations.

*EXAMPLES*

1. *Boom spraying, broadcast.* Spray 30 GPA at 5 mph with a 20-inch nozzle spacing on the boom.

a.

$$GPM\ per\ nozzle = \frac{30 \times 5 \times 20}{5940} = 0.51$$

*Select an 80° or 90° flat spray nozzle to deliver 0.51 GPM at suggested psi.*

b.

$$sec\ /qt\ /nozzle = \frac{15\ (constant)}{GPM\ per\ nozzle}$$

$$sec\ /qt\ /nozzle = \frac{15}{0.51} = 29.4$$

Adjust the pressure regulator to deliver 0.38 GPM per nozzle or to deliver one quart in 40 seconds.

2. *Band spraying with one nozzle.* GPA is the amount applied to the *area actually treated.* If the 40 GPA rate is applied at 4 MPH on a 14-inch band, the 40 GPA would be used with 4 MPH and 14-inch band width in the formula given below.

a.

$$GPM\ per\ nozzle = \frac{40 \times 4 \times 14}{5940} = 0.38$$

*Select an 80° even spray nozzle to deliver .38 GPM at suggested psi.*

b.

$$sec\ /qt\ /nozzle = \frac{15}{.38} = 40$$

3. *Band spraying with two or more nozzles per band.* If two nozzles are used to spray the 40-gallon per acre rate on a 14 inch band, calibrate by using width (W) of 7 inches (14 inches ÷ 2) in formula given in Step 5 above. Collect the quart from one nozzle in the time calculated with the formula given in step 6 above.

4. *Boomless spraying, broadcast.* Spray 20 GPA at 4 MPH and cover a 40-foot swath (40 feet X 12 inches/foot).

With the tractor out of gear and the engine running at the throttle setting selected, adjust the pressure regulator so that 6.5 gallons is sprayed in one minute from the nozzle assembly. Follow steps 7 through 9 to complete calibration.

$$GPM\ per\ nozzle = \frac{20 \times 4 \times (40 \times 12)}{5940} = 6.5$$

*Select a single assembly of nozzles to deliver 6.5 GPM at suggested psi.*

5. *Spraying at a broadcast rate above 40 GPA*. Spray 50 GPA at 40 MPH with nozzles spaced 20 inches apart on the boom.

a.

$$GPM\ per\ nozzle = \frac{50 \times 4 \times 20}{5940} = .67$$

*Select an 80° or 95° flat spray nozzle to deliver .67 GPM at suggested psi.*

The time in seconds to catch one gallon from each nozzle may be determined by this formula:

b.

$$Sec\ /gal\ /nozzle = \frac{60\ (constant)}{GPM\ per\ nozzle} = \frac{60}{.67} = 89.6$$

With the tractor out of gear and the engine running at the throttle setting selected, adjust the pressure regulator so that one gallon of spray mixture is sprayed by each nozzle in 90 seconds. Follow steps 7 through 9 to complete calibration.

Table 1. Determine Speed of Application

| Step | Example | (Yours) |
|---|---|---|
| 1. Mark off and measure length of course (Feet Traveled) | 300 feet | ________ |
| 2. Time the spray rig as it crosses the course. Use gear and throttle setting you plan to use during application. (Seconds Traveled) | 51 seconds | ________ |
| 3. Calculate Speed (MPH) = (#1 × 60) ÷ (#2 × 88), or $MPH = \frac{Feet\ Traveled\ x\ 60}{Seconds\ Traveled\ x\ 88}$ | 4 mph | ________ |

Table 2. Determine Flow Rate Needed

| Step | Example | (Yours) |
|---|---|---|
| 1. Gallons per acre of spray solution to be applied (GPA) | 30 gpa | ________ |
| 2. Application speed (Table 1, Step 3) | 4 mph | ________ |
| 3. Effective width (W) (Effective width: nozzle spacing for boom spraying, band width for banding, spray swath for broadcast boomless, width of band divided by number of nozzles for multi-nozzle banding) | 20 in | ________ |
| 4. Flow rate needed from each tip (GPM) = (#1 × #2 × #3 ÷ 5940), or $GPM = \frac{GPA\ x\ MPH\ x\ W}{5940}$ | 0.4 gpm | ________ |

| Table 3. Calibration | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Flow rate needed from each tip (GPM) (Table II, Step 4) | 0.4 gpm | ________ |
| 2. Time required to collect 1 quart (32 ounces) (15 ÷ #1), or | | |
| $sec\ /qt\ /nozzle = \frac{15}{GPM}$ | 37 sec | ________ |
| 3. With tractor out of gear and engine running at the throttle setting selected, adjust pressure regulator to deliver flow rate calculated in steps 1& 2 above. | | |

| Table 4. Calculating amount of pesticide to add to tank for liquid pesticide (given pints per 100 gal recommended by label) | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Gallons in tank (GAL) | 200 gal | ________ |
| 2. Pints per 100 gallon recommended by label (pt/100gal wanted) | 2 pints | ________ |
| 3. Pints pesticide needed per tank (#1 × #2 ÷ 100), or | | |
| $\frac{GAL \times pt/100\ gal\ wanted}{100\ gal} = \frac{200 \times 2}{100} = 4\ pints\ needed$ | 4 pints | ________ |

| Table 5. Calculating amount of pesticide to add to tank (given pints per acre recommended by label) | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Gallons in tank (GAL) | 300 gal | ________ |
| 2. Pints per acre pesticide recommended by label (pt/acre wanted) | 2 pt/acre | ________ |
| 3. Gallons spray per acre to be applied (gal/acre) | 20 gal/acre | ________ |
| 4. Acres sprayed per tank (#1 ÷ #3), or | | |
| $\frac{GAL}{gal/acre} = \frac{300}{20} = 15\ acres\ /tank$ | 15 acres/tank | ________ |
| 5. Pints pesticide needed per tank (#4 × #2), or | | |
| $pints\ needed = Acres\ /tank \times pt/acre$<br>$15 \times 2 = 30\ pints\ needed$ | 30 pints needed<br>(3 gal, 6 pints) | ________ |

| Table 6. Calculating amount of pesticide to add to tank for wettable powders (given lbs per acre recommended by label) | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Gallons in tank (GAL) | 300 gal | ________ |
| 2. Pounds per acre recommended by label (lb/acre) | 2 lb/acre | ________ |
| 3. Gallons spray per acre to be applied (gal/acre) | 20 gal/acre | ________ |
| 4. Acres sprayed per tank (#1 ÷ #3), or $GAL/(gal/acre) = 300/20 = 15\ acres/tank$ | 15 acres/tank | ________ |
| 5. Pounds needed (#4 × #2), or $lb\ needed = Acres/tank \times lb/acre = 15 \times 2 = 30\ lb\ needed$ | 30 lb needed | ________ |

| Table 7. Calculating amount of pesticide to add to tank for wettable powders (given lbs per 100 gal recommended by label) | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Gallons in tank (GAL) | 300 gal | ________ |
| 2. Pounds per 100 gal recommended by label (lb/100 gal) | 2 lb/100 gal | ________ |
| 3. Pounds needed (#1 × #2 ÷ 100), or $lb\ needed = \frac{GAL \times lb/100\ gal}{100\ gal} = \frac{300 \times 2}{100} = 6\ lb\ needed$ | 6 lb needed | ________ |

| Table 8. Calculating amount of pesticide to add to tank for wettable powders (given percent active ingredient recommended by label) | | |
|---|---|---|
| **Step** | **Example** | **(Yours)** |
| 1. Gallons in tank (GAL) | 200 gal | ________ |
| 2. Percent active ingredient recommended by label (% a.i. wanted) | 3.5% | ________ |
| 3. Specific weight of carrier (water - 8.34 lb/gal) | 8.34 lb/gal | ________ |
| 4. Percent active ingredient in formulation, from label (%a.i. form.) | 80% | ________ |
| 5. Pounds needed (#1 × #2 × #3 ÷ #4), or $\frac{GAL \times \%\ a.i.\ wanted \times lb/gal}{\%\ a.i.\ form.}$ $lb\ needed = \frac{200 \times 3.5 \times 8.34}{80} = 73\ lb\ needed$ | 73 lb needed | ________ |

Table 9. Calculating amount of pesticide to add to tank (given percent active ingredient recommended by label)

| Step | | Example | (Yours) |
|---|---|---|---|
| 1. | Gallons in tank (GAL) | 100 gal | ________ |
| 2. | Percent active ingredient recommended by label (% a.i. wanted) | 1% | ________ |
| 3. | Specific weight of carrier (water - 8.34 lb/gal) | 8.34 lb/gal | ________ |
| 4. | Pounds active ingredient per gallon in formulation, from label (lb a.i./gal form.) | 2 lb a.i./gal | ________ |
| 5. | Gallons emulsifiable concentrate needed (#1 × #2 × #3) ÷ (#4 × 100), or $gallons\ needed = \frac{GAL \times \%\ a.i.\ wanted \times lb\ /gal}{lb\ /gal\ a.i.\ form. \times 100} =$ $\frac{100 \times 1 \times 8.34}{2 \times 100} = 4.17\ gal\ needed$ | 4.17 gal needed | ________ |
| 6. | Need 4 gallons plus (0.17 gal x 128 ounces/gal =22 ounces) | 4 gal, 22 ounces | ________ |

# THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at http://www.agen.tamu.edu/arroyo.



Cooperative Extension work in agriculture and family and consumer sciences, The Texas A&M University System, and the United States Department of Agriculture cooperative. Distributed in furtherance of the acts of Congress of May 8, 1914, as amended June 30, 1914.
10/96

# APPENDIX C

## Approved Quality Assurance Project Plan

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

FEB 5 1996

Mr. Arthur Talley, Team Leader
Nonpoint Source Program (MC 150)
Water Planning and Assessment Division
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087

Re: Approval of the Quality Assurance Project Plans (QAPPs) for the Pace Bend Park Watershed Restoration, Assistance ID No. C9-996146-02-0 FY 94 Nonpoint Source Grant and The Arroyo Colorado Project, Assistance ID No. C9-006975-92-2, FY 92

Dear Mr. Talley:

The above QAPPs which were sent to us on November 28 and November 30, 1996, respectively have been reviewed and are approved. Any extra copies of the QAPPs we received, and the completed signature pages are enclosed.

We appreciate your efforts in support of generating quality data for the Nonpoint Source Program. If you have any questions, please call me at (214) 665-8086.

Sincerely yours,

Len A. Pardee

Len A. Pardee
Texas Nonpoint Source Program
U.S. EPA Region 6

Enclosures (4)

cc: Carol Whittington, TNRCC

**TEXAS STATE SOIL AND WATER CONSERVATION BOARD**

311 North 5th
P.O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

June 24, 1997

Mr. Kelvin Moore
Program Administrator (MC-150)
Watershed Assessments and Planning Section
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087

**RE: Annual QAPP Revision for FY92 319(h) Project Entitled "Arroyo Colorado NPS Project"**

Dear Mr. Moore:

Enclosed for your review and approval is the annual QAPP revision for above-referenced project along with (4) signed approval pages. I believe this QAPP meets all of the requirements for a Category III QAPP as outlined in the EPA QA/R-5 document issued by Region 6.

In addition, I have not received an official reply to my letter sent to you on April 21, 1997 regarding the last date that bills can be processed for this project. Please respond to this letter as soon as possible.

Thank you for your assistance in this matter. Please call if you have any questions.

Sincerely,

Justin Hester
Planner I

Enclosures

# 1st Annual Revision to the Quality Assurance Project Plan for the Environmental Measurement Activities Relating to Arroyo Colorado NPS Project Located in Cameron County, Texas

**Texas State Soil and Water Conservation Board**
**Temple, Texas**

**Quality Assurance Management Plan (Q-97-102)**
**Texas State Soil and Water Conservation Board**

United States Environmental Protection Agency, Region VI

Name: Len Pardee
Title: Texas Nonpoint Source Project Manager
Signature:________________________________Date:_____________

Name: Richard G. Hoppers
Title: Quality Assurance Manager
Signature:________________________________Date:_____________

Texas Natural Resources Conservation Commission

Name: Kelvin Moore
Title: Grant Manager
Signature:________________________________Date:_____________

Name: Clyde E. Bohmfalk
Title: Quality Assurance Officer
Signature:________________________________Date:_____________

Texas State Soil and Water Conservation Board

Name: Byron Spoonts
Title: Agricultural Project Administrator
Signature: ____________ Date: 6/25/97

Name: Justin Hester
Title: Agricultural Project Manager
Signature: ____________ Date: 6/28/97

Texas Institute for Applied Environmental Research

Name: Larry Hauck
Title: Assistant Director of Environmental Sciences
Signature: ____________ Date: 5/28/97

Name: Mark Murphy
Title: Laboratory Manager
Signature: ____________ Date: 5/29/97

Name: Joan Flowers
Title: Project Manager
Signature: ____________ Date: 5/28/97

Name: Nancy Easterling
Title: Quality Assurance Manager
Signature: ____________ Date: 5/28/97

Southmost Soil and Water Conservation District

Name: Wayne Halbert
Title: Quality Assurance Coordinator
Signature: ____________ Date: 6/12/97

Texas State Soil and Water Conservation Board

Name: Byron Spoonts
Title: Agricultural Project Administrator
Signature: ______________ Date: 6/23/97

Name: Justin Hester
Title: Agricultural Project Manager
Signature: ______________ Date: 6/23/97

Texas Institute for Applied Environmental Research

Name: Larry Hauck
Title: Assistant Director of Environmental Sciences
Signature: ______________ Date: 5/28/97

Name: Mark Murphy
Title: Laboratory Manager
Signature: ______________ Date: 5/29/97

Name: Joan Flowers
Title: Project Manager
Signature: ______________ Date: 5/28/97

Name: Nancy Easterling
Title: Quality Assurance Manager
Signature: ______________ Date: 5/28/97

Southmost Soil and Water Conservation District

Name: Bailey Dunlap, Jr.
Title: Quality Assurance Coordinator
Signature: ______________ Date: 6-12-97

## Section A2: Table of Contents

## Section A3: Distribution List

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

- United States Environmental Protection Agency, Region VI

  Name: Len Pardee
  Title: Texas Nonpoint Source Project Manager

  Name: Richard G. Hoppers
  Title: Quality Assurance Manager

- Texas Natural Resource Conservation Commission

  Name: Kelvin Moore
  Title: Grant Manager

  Name: Clyde E. Bohmfalk
  Title: Quality Assurance Officer

- Texas State Soil and Water Conservation Board

  Name: Byron Spoonts
  Title: Agricultural Project Administrator

  Name: Justin Hester
  Title: Agricultural Project Manager

  Name: Bobbie Stephens
  Title: Contract Manager

- Texas Institute for Applied Environmental Research

  Name: Larry Hauck
  Title: Assitant Director of Environmental Sciences

  Name: Mark Murphy
  Title: Laboratory Manager

  Name: Joan Flowers
  Title: Project Manager

  Name Nancy Easterling
  Title: Quality Assurance Manager

- Southmost Soil and Water Conservation District

  Name: Wayne Halbert
  Title: Quality Assurance Coordinator

## Section A4: Project/Task Organization

The following is a list of individuals and organizations participating in the project with their specific roles and responsibilities:

**Len Pardee, Nonpoint Source Project Manager**
United States Environmental Protection Agency (EPA)
Region VI, Dallas
Responsible for overall performance and direction of the project at the Federal level. Approves the final products and deliverables.

**Richard G. Hoppers, Quality Assurance Manager**
United States Environmental Protection Agency (EPA)
Region VI, Dallas
Responsible for determining that the Project Plan meets the Federal requirements for planning, quality control, quality assessment, and reporting.

**Kelvin Moore, Grant Manager (512) 239-4548**
Texas Natural Resource Conservation Commission (TNRCC)
Water Planning and Assessment Division
Responsible for tracking project progress and expenditures.
Reports project status to the EPA.

**Clyde Bohmfalk, Quality Assurance Officer (512) 239-4623**
Texas Natural Resource Conservation Commission (TNRCC)
Water Planning and Assessment Division
Responsible for determining that the project activities meet the federal Quality Assurance Project Plan (QAPP) requirements.

**Bo Spoonts, Agricultural Project Administrator (817) 773-2250**
Texas State Soil and Water Conservation Board (TSSWCB)
Responsible for tracking project administration.

**Justin Hester, Agricultural Project Manager (817) 773-2250**
Texas State Soil and Water Conservation Board (TSSWCB)
Responsible for overseeing the implementation of the proposed demonstration sites.

**Bobbie Stephens, Contract Manager (817) 773-2250**
Texas State Soil and Water Conservation Board (TSSWCB)
Responsible for tracking project progress and expenditures

**Larry Hauck, Assistant Director of Environmental Sciences (817) 968-9561**
Texas Institute for Applied Environmental Research (TIAER)
Tarleton State University
Responsible for project administration.

**Joan Flowers, Project Manager**
Texas Institute for Applied Environmental Research
Responsible for coordination of field sampling, monitoring, laboratory analysis and modeling portions of project.

**Nancy Easterling, Quality Assurance Manager (817) 968-9548**
Texas Institute for Applied Environmental Research (TIAER)
Tarleton State University
Responsible for determining that the Project Plan meets the requirements for planning, quality control, quality assessment and reporting.

**Mark Murphy, Laboratory Manager (817) 968-9564**
Texas Institute for Applied Environmental Research (TIAER)
Tarleton State University
Responsible for TIAER analytical laboratory operations for this project.

**Wayne Halbert, Quality Assurance Coordinator (210) 423-7015**
Southmost Soil and Water Conservation District (SWCD)
Responsible for overseeing the performance of water sampling and shipment of water samples on the demonstration sites in Cameron county according to guidelines outlined in the QAPP.

**Allan Moore, Engineer (210) 399-2522**
Natural Resources Conservation Service (NRCS)
Responsible for overseeing the location, design, and installation of monitoring equipment on the demonstration sites.

**Guy Fipps, Extension Specialist (409) 845-3977**
Texas Agricultural Extension Service (TAEX)
Responsible for overseeing the evaluation of BMP effectiveness and implementation of educational workshops and seminars.

**Technical Advisory Committee**
This committee was formed to ensure that the technical activities of this project are properly addressed.

**Local Advisory Committee**
This committee was formed to ensure that the citizens along the Arroyo are informed on the progress of the project and have a opportunity to provide input and express concerns on the activities and direction of the project.

## Section A4: Project Organization Chart

- Len Pardee (EPA)
  - Richard Hoppers (EPA)
- Kelvin Moore (TNRCC)
  - Clyde Bohmfalk (TNRCC)
- Bo Spoonts (TSSWCB)
  - Justin Hester (TSSWCB)
  - Bobbie Stephens (TSSWCB)
- Larry Hauck (TIAER)
  - Nancy Easterling (TIAER)
  - Mark Murphy (TIAER)
  - Joan Flowers (TIAER)
- Wayne Halbert (Southmost SWCD)
- Allan Moore (NRCS)
- Guy Fipps (TAEX)
- Technical Advisory Committee
- Local Advisory Committee

## Section A5: Problem Definition/Background

The Lower Rio Grande Valley serves as an intensive agricultural region of Texas. Major crops, grown predominantly under irrigation, include citrus, grain, sugar cane, cotton and vegetables. The source of irrigation water is the Rio Grande River. Area soils are naturally saline and this problem is complicated by a shallow, saline water table (five to seven feet). Drawdown of the water table is conducted by sub-surface drainage systems which have been installed to much of the irrigated land to mitigate toxic salt buildup. This water is then released to the Arroyo Colorado.

The Arroyo Colorado is one of the more complex watercourses in the state. From its headwaters to its mouth, it has been extensively modified by the activities of man, which is reflected in both its hydrology and its water quality. Its lowest reach is estuarine, and issues into the Laguna Madre, an extremely productive, high-salinity embayment lying behind the barrier of Padre Island. The lower reach of the Arroyo is terminated by a fluvial delta system. However, the main channel of the Arroyo itself has been dredged for navigation, accommodating light draft traffic such as commercial fishing boats, barges and pleasure craft.

The watershed of the Arroyo Colorado is principally agricultural, though the Arroyo also drains the urban areas of Harlingen, McAllen and intervening areas, and therefore is subject to urban runoff as well. Under low flows, the river is dominated by municipal effluents from these communities. Under storm flow, it receives runoff from both municipal and agricultural areas. Both types of runoff are highly influenced by alterations to the watershed. The low-relief, arid region is artificially plumbed by canals, aqueducts, siphons and pumping stations to provide irrigation water for the vast agricultural enterprises of the region. This same plumbing greatly influences the timing and volume of runoff. Similarly, the drainage of the urbanized areas consists of rectified, levied, intersecting channels with gates for controlling and directing the flow. The runoff response of the Arroyo is therefore quite different from what one would expect on the basis of natural runoff processes.

This is further complicated by the extreme events which create flood stages on the Rio Grande River. Such events activate floodway systems that divert floodwaters through the upper Arroyo Colorado channel, making the Arroyo watershed, effectively, that of the Rio Grande. Quality of water in the Arroyo has been historically variable. At low stage, it exhibits all the problems expected of an effluent-dominated system in a hot, arid climate: high coliforms, low dissolved oxygen and high algal concentrations. In the estuarine reach these are exacerbated by the circulations associated with salinity intrusion in a deepened channel. These same areas act as sinks for silt and muds, which frequently bind hygroscopic contaminants. During flood events, the water may be affected (depending upon the characteristics of the storm and the operations of the drainageways) by urban and agricultural contaminants, especially pesticides. Past studies of the Corps of Engineers and Texas Water Development Board have demonstrated the accumulation of pesticides in the deltaic sediments such as Malathion degradation products.

There are several agricultural BMPs that are commonly used on agricultural fields in the Arroyo Colorado Watershed which include:

- The use of conservation cropping rotations to maintain or improve soil conditions.
- The use of crop plant residues to protect fields during critical erosion periods.
- The use of pest management to control agricultural pest infestations such as weeds and insects that effect plant growth and crop production.
- The use of nutrient management to control the amount, form, and placement of nutrients applied to agricultural fields.

This project will encourage the voluntary adoption of best management practices (BMPs) for controlling and preventing non-point source pollution from dryland and irrigated croplands. The approach is to establish demonstration sites on area dryland and irrigated farms where local farmers and organizations can observe the benefits and effectiveness of specific BMPs.

There will be three best management practices implemented on the dryland demonstration site. The first BMP that will be used is nutrient management which prescribes split-application of nutrients and determination of residual amount of nutrients in the soil. The second BMP that will be utilized is crop plant residue management. The project will determine if crop plant residues left on the treated field result in less constituents leaving the site. The final BMP that will be utilized is precision land forming which is reshaping the surface of a field into planned grades.

There will be two best management practices implemented on the irrigated demonstration site. The first BMP that will be used is irrigation management. This management practice will focus on how improved irrigation technology, the frequency that the fields are irrigated, and the volume of water placed on the fields affect the quality and quantity of water discharged from site. The other BMP that will be used is nutrient management and will utilize split-application of nutrients and determine the residual amount of nutrients in the soil.

The project will also develop educational materials and support the transfer of demonstration results to other sites and areas.

## Section A6: Project/Task Description

The NPS Prevention in the Arroyo Colorado Watershed Project will be a multidiscipline effort to demonstrate and evaluate the effectiveness of selected BMPs to reduce nutrient and pesticide loading of the Arroyo Colorado Watershed.

The purpose of this project is to collect sufficient data on two demonstration sites to determine if the installation of BMPs significantly improves water quality. The concentration of nutrient and pesticide levels before and after installation of BMPs will be used to determine the effectiveness of selected BMPs in reducing nutrient and pesticide loading to the Arroyo Colorado Watershed.

The Arroyo Colorado project will implement two demonstration sites and determine their effectiveness in abating nonpoint source pollution associated with agricultural runoff. The first demonstration site will be on 60 acres of dryland cropland in Cameron County. A map of the dryland demonstration site (Attachment B1-4) is shown on page 22 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs.

There will be three best management practices implemented on the dryland demonstration site. The first BMP to be used is nutrient management. On the control site standard nutrient application methods will be utilized. On the treated site split-application of nutrients will be applied and the residual amount of nutrients in the soil will be identified to determine correct nutrient application rates. The use of split-applications of nutrients allows the application to occur during a plants growing cycle when the plants can use the nutrients most efficiently. The second BMP that will be utilized is crop plant residue management. At the dryland demonstration site, crop plant residue management will be utilized on the treated fields at a minimum rate of 2000 pounds per acre. On the control field, the crops will be tilled into the soil and will not be left remaining on the surface of the field as a residue. The final BMP that will be utilized is precision land forming which is reshaping the surface of a field into planned grades. The control site will not have precision land forming implemented on the site. However, the treated site will have precision land forming implemented on the site which will control erosion and constituents leaving the site.

The second demonstration site will be on 40 acres of irrigated cropland in Cameron County. A map of the irrigated demonstration site (Attachment B1-5) is shown on page 23 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs. The project will utilize a subsurface drainage monitoring system located on the treated and control field to monitor the impact of BMPs on the irrigated cropland.

There will be two best management practices implemented on the irrigated demonstration site. The first BMP that will be used is irrigation management. This management practice will focus on how improved irrigation technology, the frequency that the fields are irrigated, and the volume of water placed on the fields effect the quality of water discharged from site. The other BMP that will be used is nutrient management. On the control site standard nutrient application methods will be utilized on the site. On the treated site split-applications of nutrients will be applied to the site and the residual amount of nutrients in the soil will be identified to determine correct application rates of nutrients. The use of split-applications of nutrients allows the application of nutrients to occur during a plants growing cycle when the plants can use the nutrients most efficiently.

Water samples collected from the two demonstration sites in Arroyo Colorado Watershed will be analyzed for the presence of nitrates, orthophosphates, pesticides, and total suspended solids. The pesticides that will be analyzed during this project have been used on the dryland and irrigated demonstration sites in the past few years and will be used on these sites during the project. Water samples will be collected on the dryland site when a rainfall runoff event occurs and on the irrigated site when an irrigation or rainfall event results in subsurface drainage.

During the course of the project, BMPs will be designed and implemented prior to water sampling. At the conclusion of water sampling, BMPs will be evaluated to determine their effectiveness in limiting NPS pollution. Mathematical model(s) will also be applied to individual fields and agriculturally dominated regions of the project area to show BMP system efficiency. The models that will be used include EPIC, EPIC-WT, and DRAINMOD and the models will be verified using data from the demonstration sites. The model(s) used in the final analysis will depend upon the validated individual model(s) performance. Edge-of-field load reductions for nutrients, pesticides and sediment will be calculated for the demonstration sites and estimated for the project area.

The Southmost SWCD will be primarily responsible for the installation of demonstration sites. The NRCS will be primarily responsible for the installation of monitoring equipment. Water sample collection will be performed by the Southmost SWCD. TIAER will be primarily responsible for laboratory analysis of water samples. TAEX will analyze the monitoring data and determine the effectiveness of the BMPs. TIAER will apply mathematical model(s) to individual fields and agriculturally dominated regions of the project area. Edge-of-field load reductions for nutrients, pesticides and sediment from BMPs will be calculated for the demonstration sites and estimated for the project area. The educational and technology activities will be done by TAEX. Table A6-1 lists the monitoring plan milestones.

**Table A6-1 Monitoring Plan Milestones**

| | | |
|---|---|---|
| Nov | 1995 | Install BMPs on treated fields |
| Nov | 1995 | Monitoring equipment installed and monitoring initiated |
| July | 1997 | Conclusion of water quality sampling |
| July | 1997 | Draft Project reports on modeling results and BMP effectiveness submitted. |
| Aug | 1997 | Final Project reports on modeling results and BMP effectiveness submitted. |

## Section A7: Data Quality Objectives for Measurement Data

Nonpoint source pollution generated from the agriculture industry has the potential for contaminating surface water resources in the Arroyo Colorado Watershed. The project's data quality objective is to demonstrate water quality improvements from BMPs designed to reduce nutrient and pesticide stormwater loadings from agricultural fields. BMPs will be evaluated in their effectiveness to a confidence level of 90 percent. The project hosts a number of participants including:

1) US Environmental Protection Agency, Region VI (EPA)
2) Texas State Soil and Water Conservation Board (TSSWCB)
3) Texas Natural Resource Conservation Commission (TNRCC)
4) Texas Institute for Applied Environmental Research (TIAER)
5) Texas Agricultural Extension Service (TAEX)
6) Natural Resources Conservation Service (NRCS)
7) Southmost Soil and Water Conservation District (SWCD)
8) Local landowners

This project will demonstrate the effectiveness of selected agricultural BMPs to reduce nutrient and pesticide loading in the Arroyo Colorado Watershed. For the two demonstration sites, when sufficient overland water flow exists, water samples will be collected from the sites. To aid in evaluating BMPs, mathematical model(s) will be used. Edge-of-field load reductions for nutrients, pesticides and sediment will be calculated for the demonstration sites and estimated for the project area.

Automatic ISCO water samplers will be utilized to collect water samples during stormwater runoff events. Water samples will be collected from the demonstration sites (a maximum of 8 runoff events or 48 samples / year and a minimum of 3 runoff events or 18 samples / year for each demonstration site). However, the number of samples that can be collected at the demonstration sites is totally dependent upon the weather conditions. Concurrent flow data will provide information to locate the beginning, peak and end of stormwater runoff events at each site. Concurrent flow data will be estimated from water levels with standard open-channel flow equations such as the Chezy-Manning equation for the irrigated demonstration site and wier discharge equations for the dryland demonstration sites. The ISCO 3700 water samplers will be set up to catch the first flush of runoff from the demonstration sites when sufficient flow exist. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3). Samples for analysis will be selected based on the following criteria: Samples will be analyzed within the estimated accuracy and precision limits of measured parameters to insure data quality (Table A7-1). The accuracy limits shown in (Table A7-) are for the laboratory data quality and not water quality.

Because generalized fertilizer recommendations often result in an increased risk in excessive fertilizer application, soil samples will be taken at each treatment site and analyzed for nutrients and texture in order to determine the appropriate fertilizer rates. These soil samples will be analyzed by the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory. Estimated determinations for precision and accuracy for laboratory analyses, based on an extensive database, are outlined in Table A7-2.

**Table A7-1 Estimated Accuracy and Precision Limits of Measured Water Parameters**

| Nutrient/pollutant | Processing Agency | Precision Limits (PD)* | Accuracy Limits ** | Estimated Practical Quantity Limits *** |
|---|---|---|---|---|
| Conductivity | TIAER | 10% | 90-110% | 10 µmhos/cm |
| Total Suspended Solids | TIAER | 10% | NA | 50 mg/L |
| Chemical Oxygen Demand | TIAER | 10% | 80-120% | 30 mg/L |
| Nitrate-Nitrite Nitrogen | TIAER | 10% | 80-120% | 0.030 mg/L |
| Orthophosphate - Phosphorous | TIAER | 10% | 80-120% | 0.050 mg/L |
| Ammonia Nitrogen | TIAER | 10% | 80-120% | 0.185 mg/L |
| Total Kjeldahl Nitrogen | TIAER | 10% | 80-120% | 0.97 mg/L |
| Total Phosphorus | TIAER | 10% | 80-120% | 0.505 mg/L |
| Parathion (methyl) | TIAER | 12% | 61- 123% | 0.059 µg/L |
| Azinphos-methyl | TIAER | 10% | 37- 127% | 0.03 µg/L |
| Malathion | TIAER | 10% | 66- 118% | 0.036 µg/L |
| Permethrin (cis) | TIAER | 29% | 41- 157% | 0.66 µg/L |
| Permethrin (trans) | TIAER | 29% | 41- 157% | 0.66 µg/L |
| Trifluralin | TIAER | 15% | 3- 177% | 0.16 µg/L |
| Prometryn | TIAER | 30% | 10-110%† | 0.20 µg/L |
| Atrazine | TIAER | 20% | 31- 132% | 0.500 µg/L |

* Percent Deviation
** These represent the maximum allowable accuracy limits. Typically the actual accuracy limits will be narrower.
*** PQL determined by multiplying MDL by 5.0
† Determined in the TIAER laboratory

NA Not applicable
mg/L milligrams per liter
µg/L micrograms per liter
µmhos/cm miromhos per centimeter

**Table A7-2 Accuracy and Precision Limits of Measured Soil Parameters**

| Parameter | Processing Agency | Precision Limits | Accuracy Limits | PQL |
|---|---|---|---|---|
| Nitrate-nitrogen | TAEX | 4% | 30% | 0.05 mg/kg |
| Phosphorus | TAEX | 4% | 5% (acid soils) | 0.05 mg/kg |
| pH | TAEX | 0.3% | 1% | 4-10 |
| Potassium | TAEX | 22% | 8% | 5 mg/kg |
| Calcium | TAEX | 2% | 15% (acid soils) | 1 mg/kg |
| Magnesium | TAEX | 4% | 6% (acid soils) | 1 mg/kg |
| Sodium | TAEX | 25% | 9% | 5 mg/kg |
| Sulfate | TAEX | 14% | not determined | 0.500 μg/L |

PQL = Practical Quantity Limits

Data collection and analyses will meet an 90 percent data completeness. These data will be presented as mean levels for evaluation. Statistical comparison of BMPs will include analysis of variance with a 90 percent level of confidence. Although 100 percent of collected data should be available, accidents, insufficient sample volume, or other problems must be expected. A goal of 90 percent data completeness will be required for data usage. If less than 90 percent data completeness occurs, the Program Manager will initiate corrective action. Data completeness will be calculated as a percent value and evaluated with the following formula:

$$\% \text{ completeness} = \frac{SV}{ST} \times 100$$

Where: SV = number of samples with a valid analytical report
ST = total number of samples collected

The TIAER Laboratory will determine the precision of its analyses. This will be accomplished by repeating the entire analysis of a sample once per batch or once per 10 samples which ever is the greater frequency. Percent deviation of duplicate analyses ($X_1$ and $X_2$) will be calculated using the formula:

$$\text{Percent Deviation} = \frac{(X_1 - X_2)}{(X_1+X_2)} \times 100\%$$

Where: $X_1$ = larger of the two observed values
$X_2$ = smaller of the two observed values

The accuracy of the analytical process will be monitored by determining the percent recovery of a spike quantity of the parameter in question once per batch or once per 10 samples which ever is the greater frequency. The following formula will be utilized to determine percent recovery:

$$\%\ \text{Recovery} = \frac{SSR-SR}{SA} \times 100$$

Where: SSR = spiked sample result
SA = spike added
SR = sample un-spiked result

The accuracy of water samples collected will be reviewed by taking equipment blanks on 5% of the samples collected. This would amount to collecting a equipment blank once per 20 samples collected at each demonstration site. This will be accomplished by taking samples of deionized water through the ISCO samplers and sending the samples to the TIAER Laboratory for analyzes.

The Quality Assurance Manager will review the data for abnormalities or any unusual results. Any of these that occur will be traced back looking for sources of error. In the event no error is found, the data will be assumed normal and appropriate for decision determinations. If an error is found and cannot be resolved then the data will be discarded.

The Quality Assurance Manager will coordinate with the Project Manager and the laboratory supervisor to ensure that proper protocols are utilized. Table A7-1 shows the study limits established for accuracy and precision.

## Section A10: Documentation and Records

Reporting will include quarterly progress reports, reimbursement requests, and a final report at the culmination of the project.

Quarterly progress reports will note activities conducted throughout the quarter, items or areas identified as potential problems. Any changes or amendments to the QAPP will be submitted for approval prior to implementation. Corrective Action Report forms(CARs) will be utilized by TIAER when necessary (Attachment A10-1). CARs will be included in TIAER's annual quality assurance report and will be available to project participants, upon request.

Laboratory results with a summary of data to date will be prepared periodically and distributed to project participants upon request. Variations from the QAPP and subsequent CARs will be filed by the responsible agency. CARs relating to analysis of water samples will be filed by the TIAER laboratory manager.

Reimbursement requests for TIAER will be handled by the Tarleton State University accounting office in Stephenville. Reimbursement requests for NRCS will be handled by the NRCS Financial Management Section in Temple. Reimbursement requests for SWCD will be handled by the SWCD staff in Harlingen.

The final report will include results of laboratory and statistical analyses with a summary of the data that was collected during the course of the project. Hard copies of all raw data, laboratory analyses, documentation records, calibration logs, and other pertinent information will be available for inspection. All original data, both hardcopy and electronic forms, will be archived by TIAER for at least 5 years.

**Attachment A10-1 Corrective Action Report (CAR) Form**

**Corrective Action Report**

**CAR #:** ________________

Date:____________ Area/Location:________________

Reported by:__________________ Activity:______________________

State the nature of the problem, nonconformance or out-of-control situation:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Possible causes:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Recommended Corrective Actions:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

CAR routed to:________________________
Received by:__________________________

Corrective Actions taken:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Has problem been corrected: YES NO

Quality Assurance Coordinator:___________________________

Project Manager:______________________________

Quality Assurance Officer:________________________

Laboratory Manager:______________________________

## Section B1: Sampling Process Design (Experimental Design)

This project is designed to target two demonstrations sites within segment 2202 of the Arroyo Colorado Watershed. Work to be completed on the demonstration sites includes: implementing appropriate NPS pollution control BMPs, identifying the levels of contamination after BMP implementation, and demonstrating any resultant changes in water quality. The waterborne constituents which will be measured to demonstrate BMP effectiveness are shown in Table B1-1.

Two demonstration sites will be installed and their effectiveness in abating nonpoint source pollution associated with agricultural runoff will be determined. The first demonstration site will be on 60 acres of dryland cropland. A map of the dryland demonstration site (Attachment B1-4) is shown on page 22 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs (see section A-6 for list of BMPs) .

The second demonstration site will be on 40 acres of irrigated cropland in Cameron County. A map of the irrigated demonstration site (Attachment B1-5) is shown on page 23 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs. The project will utilize a subsurface drainage monitoring system located on the treated and control field to monitor the application of BMPs on the irrigated cropland (see section A-6 for list of BMPs).

In order to assess whether selected BMPs will reduce nutrient and pesticide loading of the Arroyo Colorado Watershed, water samples will be taken at the two demonstration sites. Stormwater runoff will be collected in these locations with ISCO automatic sampling devices during each rainfall event that is of sufficient intensity and duration to trigger the automatic sampling devices. Stormwater runoff samples will be collected from each demonstration site up to a maximum of 8 runoff events or 48 samples / year and a minimum of 3 runoff events or 18 samples / year for each demonstration site(Table B1-2). Sampling on the demonstration sites will be completely weather dependent so fewer than 48 samples may occur. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3). The timing of when samples are collected may be adjusted based upon individual site response. The dryland demonstration site will have earthen berms separating the site from other adjacent fields and a earthen berm separating the control and treated fields from each other.

In order to determine appropriate fertilizer application rates at the two treatment sites, soil samples will be collected and analyzed. Approximately 30 random samples will be taken per treatment site for a total of 60 samples each year and a 120 samples for two years. Samples will be taken at depths of 0 to 6", 6 - 12", 12 - 18", 18 -24", and 24-36".

This project will evaluate BMP effectiveness at a confidence level of 90 percent over the sampling period. Water quality data collected from the irrigated and dryland sites with and without BMP implementation will be compared to demonstrate BMP effectiveness.

**Table B1-1 Waterborne Constituents**

| Parameter | Reporting Units |
|---|---|
| Conductivity | µmhos/cm |
| Chemical Oxygen Demand | mg/L |
| Total Suspended Solids | mg/L |
| Ammonia Nitrogen | mg/L |
| Total Kjeldahl Nitrogen | mg/L |
| Nitrate-Nitrite Nitrogen | mg/L |
| Orthophosphate Phosphorous | mg/L |
| Total Phosphorous | mg/L |
| Methyl Parathion | µg/L |
| Azinphos-methyl | µg/L |
| Malathion | µg/L |
| Permethrin (cis/trans) | µg/L |
| Trifluralin | µg/L |
| Prometryn | µg/L |
| Atrazine | µg/L |

**Table B1-2 Number of Samples**

| Sample Type | Agency | Maximum Number of Samples per Year | Minimum Number of Samples per Year |
|---|---|---|---|
| Runoff Treated Irrigated Site | SWCD | 48/year | 18/year |
| Runoff Control Irrigated Site | SWCD | 48/year | 18/year |
| Runoff Treated Dryland Site | SWCD | 48/year | 18/year |
| Runoff Control Dryland Site | SWCD | 48/year | 18/year |

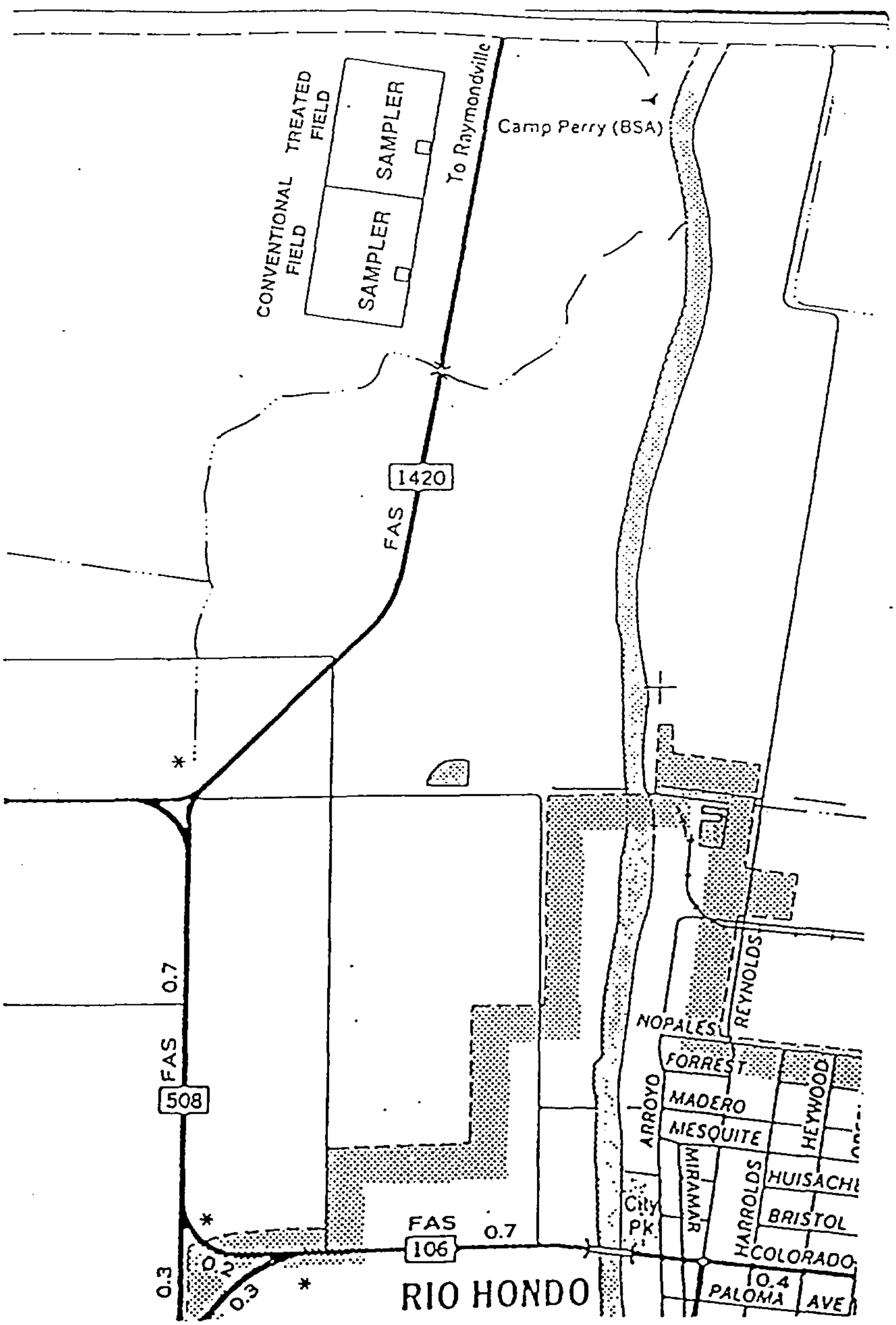
* Minimum desired number of samples; however, actual number of samples is dependent upon weather conditions.

**Table B1-3 Demonstration Sites Time Sampling Regimes**

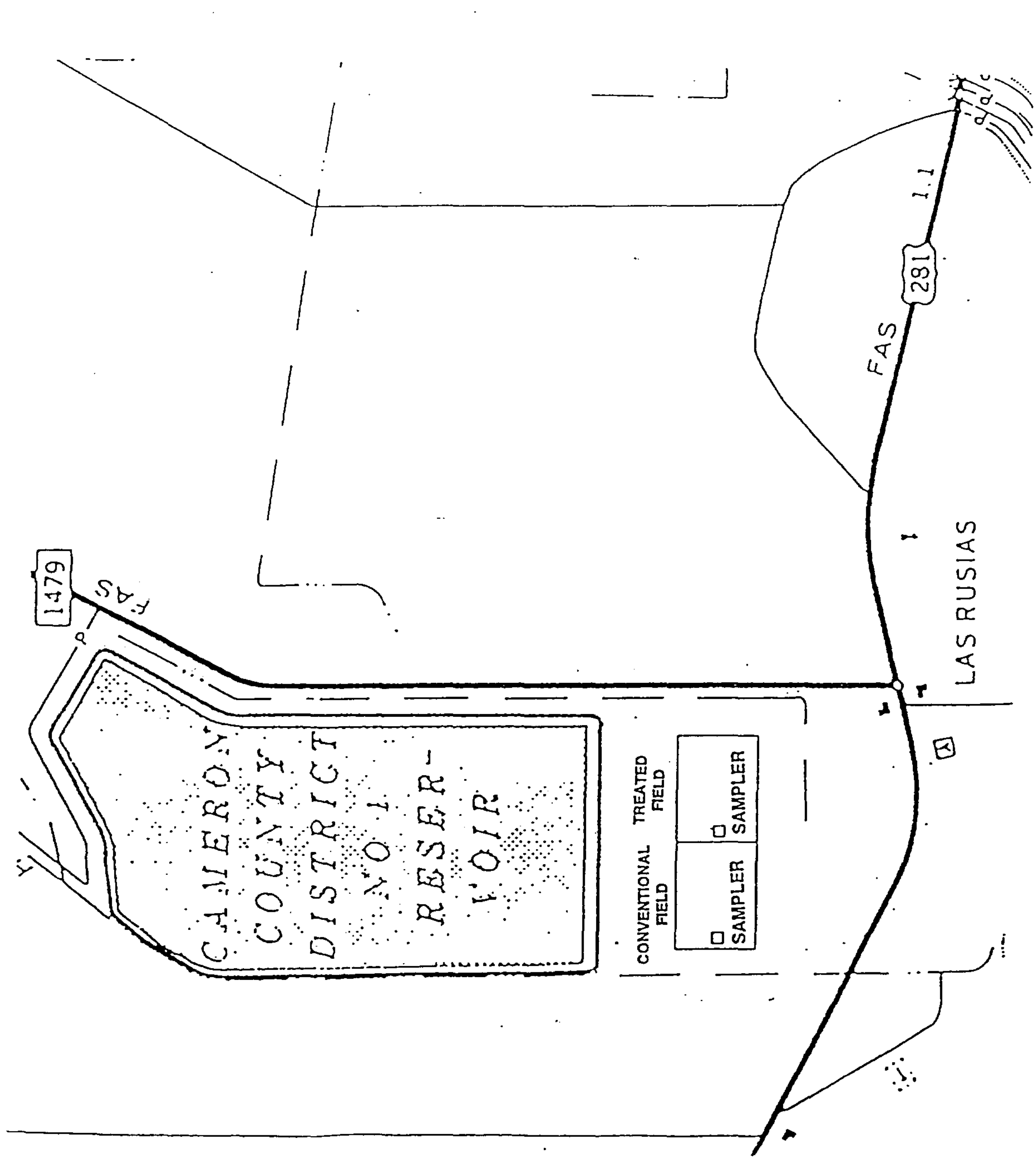
| Sample Number | Dryland Site Overland Flow * | Irrigated Site Subsurface Flow * |
|---|---|---|
| # 1 | Time 0.0 Hours | Time 0.0 Hours |
| # 2 | Time 1.0 Hours | Time 3.0 Hours |
| # 3 | Time 3.0 Hours | Time 6.0 Hours |
| # 4 | Time 6.0 Hours | Time 12.0 Hours |
| # 5 | Time 9.0 Hours | Time 18.0 Hours |
| # 6 | Time 12.0 Hours | Time 24.0 Hours |

* All times referenced to sampler activation time of 0.0 hours.

**Attachment B1-4 Location Map for Dryland Demonstration Site**



**Attachment B1-5 Location Map for Irrigated Demonstration Site**



## Section B2: Sampling Methods Requirements

Emphasis during this project will be placed on sampling stormwater runoff from two agricultural demonstration sites. Stormwater runoff samples will be collected with automatic sampling equipment. Each unit will consist of a weatherproof, lockable instrument shelter; a solar / battery powered system and a timer controlled ISCO Model 3700 Water Sampler. A pressure transducer will be used on the dryland demonstration sites to activate the samplers when the water rises to a predetermined level. The pressure transducers will be used to measure the elevation of water above the transducer and this data will be stored on a data logger on a continual basis. A float and pulley system will be used on the irrigated demonstration site to activate the samplers when the water rises to a predetermined level. The float and pulley system will be connected to a data logger which will record the water level elevation within the drainage tile on a continual basis.

Up to 6 samples may be collected as the ISCO 3700 water sampler contains a set of 12 one liter glass bottles. For the laboratory to analyze the samples received one liter of water must be collected for pesticides and one liter of water for other constituents, i.e., two one liter bottles comprise a single sample.

Water samples will be collected with the automated water samplers when the water level rises to a predetermined point. Concurrent flow data will provide information to locate the beginning, peak and end of stormwater runoff events at each site. Flow will be estimated from water levels with standard open-channel flow equations such as the Chezy-Manning equation for the irrigated demonstration site and wier discharge equations for the dryland demonstration sites. The ISCO 3700 water samplers will be set up to catch the first flush of runoff from the demonstration sites when sufficient flow exist. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3).

Soil samples will be taken at depths of 0-6", 6-12", 12-18", 18-24" and 24-36". Samples will be mailed to the TAMU Soil Testing Lab at College Station for analysis. Soil samples will be collected following recommendations made by TAEX (attachment B2-1)

All automatic sampling equipment will be inspected at least once every two weeks and serviced as needed. Sample collection at the demonstration sites will be performed by the Southmost SWCD Quality Assurance Coordinator or his representative. After a rainfall event, the ISCO samplers will be inspected within 24 hours to see if water samples have been collected. If the ISCO samplers properly collected water samples, then the samples will be transported to the TIAER laboratory for analysis.

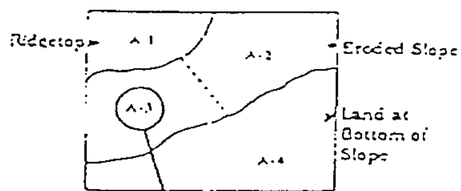
Any problems encountered during the collection of water samples will be documented with a Corrective Action Report (See Attachment A10-1). Corrective Action Reports must be documented in writing and is the responsibility of the Southmost SWCD Quality Assurance Coordinator or his representative.

# Attachment B2-1 Procedure for Taking Soil Samples

## Procedure For Taking Soil Samples

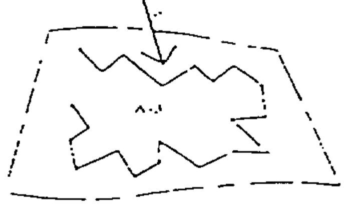
*Soil tests can be only as accurate as the samples on which they are made. Proper collection of soil samples is extremely important. Chemical tests of poorly taken samples may actually be misleading because they do not represent the area to be cropped.*

Step 1.



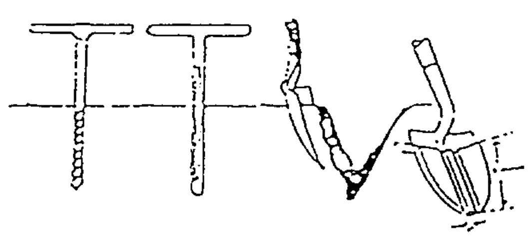

*Take one composite soil sample from each uniform area of 10 to 40 acres in a field. In areas such as East Texas, one sample should represent only 10 to 20 acres; whereas, in areas where soils are more uniform, one sample can represent up to 40 acres.*

Step 2.



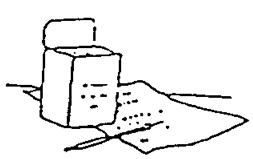

*The composite sample should be taken from each area. This can be done by taking small cores or slices from 10 to 15 different places. Place these in a clean container (plastic bucket, paper sack, etc.), mix thoroughly and take out approximately 1 pint for the composite sample.*

Step 3.



*When taking soil samples, use a spade, soil auger or soil sampling tube as illustrated. Scrape the litter from the surface. Make the core or boring 6 inches deep in the soil. (For permanent sod, sample to a depth of 3 to 4 inches) To use a spade, dig a V-shaped hole and take a 1 inch slice of soil from the smooth side of the hole. Then take a 1 X 1 inch core from the center of the shovel slice as illustrated. Repeat in 10 to 15 different places, put in a clean plastic bucket, thoroughly mix and remove a pint as a composite sample representing the field or area.*

Step 4.



*Complete the information form on the opposite side. Enclose the completed information form and payment inside the package containing samples. Make check payable to Soil Testing. DO NOT SEND CASH. Address the letter and package to one of the following addresses:*

Extension Soil, Water, and Forage Testing Laboratory
Texas A&M University - Soil & Crop Sciences
College Station, Texas 77843-2474
Phone 409/845-4816

Soil Testing Laboratory
Texas Agricultural Extension Service
Lubbock, Texas 79401-9746
Phone 806/746-6101

### Precautions

1. Avoid sampling spots in the field such as small gullies, slight field depressions, terrace waterways and unusual spots.
2. When sampling fertilized fields, avoid sampling directly in fertilized band.
3. Do not use old vegetable cans, tobacco cans, match boxes, etc., to submit samples.
4. Do not use heat to dry samples.
5. Be sure to keep a record for yourself as to the area represented by each sample.
6. Be sure sample numbers on the boxes correspond with sample numbers on the information sheet.

**For Further Details Consult Your County Extension Agent**

**Section B3: Sample Handling and Custody Requirements**

Requirements for sample handling include collection, preservation, shipping, transfer of sample custody, and storage in a manner that does not compromise sample integrity or exceed holding times for analyses. Table B3-1 delineates sample container, preservation and holding time information for parameters of interest in this project. A sample COC is included in Attachment B3-2. The sampling team will, upon collection, labeling and preservation of the samples, complete the sample description, date/time of collection information and sign the COC to transfer custody. The COC, sealed in a water proof bag, will be packed with the samples in coolers with ice, sealed with tape and shipped to the laboratory. Custody seals on sample bottles and shipping coolers will not be used on this project because the potential for litigation or fines is not expected to exist. Shipment of samples from the Harlingen area will be accomplished overnight to the Stephenville laboratory using Greyhound Bus Lines as the primary carrier. Federal Express and United Parcel Service priority shipments will be used as backup methods.

Once the samples are received at the laboratory, they will be inventoried against the accompanying COC, any discrepancies noted, and the COC will be signed for acceptance of custody. The sample numbers will then be recorded into a laboratory sample log, checked for preservation (as allowed by the specific analytical procedure), filtered or pretreated as necessary, and placed in a refrigerated cooler dedicated to sample storage.

The Laboratory Manager has the responsibility to ensure that all holding times are met. This is documented on COC for sample dates and times and on analytical run logs for analysis dates and times.

**Table B3-1 Sample Preservation and Holding Times**

| Parameter | Method | Sample Size | Container | Preservation | Holding Time |
|---|---|---|---|---|---|
| Ammonia Nitrogen | EPA 350.1 | 1 liter | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Nitrate-Nitrite Nitrogen | EPA 353.2 | 1 liter | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Total Kjeldahl Nitrogen | EPA 351.1, EPA 351.2 | 1 liter | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Orthophosphate Phosphorus | EPA 365.2 | 1 liter | AW-GB | 4°C | 28 days |
| Total Phosphorus | EPA 365.4, EPA 365.2 | 1 liter` | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Total Suspended Solids | EPA 160.2 | 1 liter | AW-GB | 4°C | 7 days |
| Conductivity | EPA 120.1 | 1 liter | AW-GB | 4°C | 28 days |
| Chemical Oxygen Demand | Hach 8000 | 1 liter | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Azinphos (methyl) | EPA 1657 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Malathion | EPA 1657 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Parathion (methyl) | EPA 1657 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Prometryn | EPA 1657 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Atrazine | EPA 1656 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Trifluralin | EPA 1656 | 1 liter | AW-GTLL | 4°C * | 7 days ** |
| Permethrin (cis/trans) | EPA 1656 | 1 liter | AW-GTLL | 4°C * | 7 days ** |

AW-GB=aluminum foil wrapped glass bottles
$H_2SO_4$=concentrated sulfuric acid
4°C= 4 degrees centigrade
AW-GTLL=aluminum foil wrapped glass with Teflon lined lid
* sodium thiosulfate must be added to 0.008% if sample contains chlorine residual
** 7 days until extraction, 40 days to analyze after extraction

## Chain of Custody Form (Attachment B3-2)
(located on the following pages)

(Attachment B3-2)

TIAER

# CHAIN OF CUSTODY

Page _____ of _____

| Project Name/No. | Project Manager/Person Requesting Sample | Samplers Name |
|---|---|---|
| | | |

| Sample No. | Color Code | Date | Time Military | Site # | Sample Type | Preservative Type | Container Type | Comments |
|---|---|---|---|---|---|---|---|---|
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |
| 10000 | | | | | | | | |

| Relinquished By: | Date: | Time: | Received By: |
|---|---|---|---|
| Relinquished By: | Date: | Time: | Received By: |

SAMPLE TYPES: V = Volunteer F = Flow Based Composite T = Time Based Composite S = Sequential G = Grab

CONTAINER TYPES: M = multiple containers P = plastic G = glass D = dark

(Attachment B3-2)

TIAER

## Water Quality Data Entry Sheet (for all samples)
## FIELD PARAMETERS ONLY!!!!!

Page _____ of _____

Entered by: Verified by:

| Sample No. | Color Code | Date | Time Military | Site # | Sample Type | Preservative Type | Container Type | Sample Dep ft | Water Temp °C | Cond µmhos | pH | Redox | D.O. mg/L | ZSD ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | |

| Received By: | Date: | Time: | Signature |
|---|---|---|---|
| | | | |

COMMENTS FOR ENTRY IN DATA COLUMNS

IM = Instrument malfunction
EF = Equipment failure
TE = Technician Error
HTE-F = Holding Time Exceeded - Field

(Attachment B3-2)

TIAER

Water Quality Data Entry Sheet (for all samples)
LABORATORY ANALYSIS ONLY!!!!

Page _____ of _____

Entered by: Verified by:

| Sample No | Color Code | Date | Time Military | Site # | Sample Type | Preservative Type | Container Type | NO2-N | NO3-N | o-PO4 | TP | NH3-N | TKN | TSS | COD | Fecal Coliform | Chl-a mg/m3 | BOD 5-day | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |
| 10000 | | | | | | | | | | | | | | | | | | | |

| Received By | Date | Time | Signature |
|---|---|---|---|
| | | | |

COMMENTS FOR ENTRY IN DATA COLUMNS

EF = Equipment Failure
TE = Technician Error
QC = Quality Control failed
STAT = Statistically close
HTE-L = Holding Time Exceeded - Lab
HTE-F = Holding Time Exceeded - Field
INT = Interference
TNTC = Too Numerous To Count

## Section B4: Analytical Methods Requirements

Only EPA approved methods shall be used for analytical data collection in accordance with 40 CFR 136. Documentary logs shall be maintained for instrument maintenance and calibration, sample extractions, standard and matrix spiking preparations. Table B4-1 delineates specific methods of analyses with equipment and instruments to be used and estimated method detection limits. Sample analysis will be performed by the Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. Glassware and labware shall be cleaned according to the specific method requirements. Corrective actions shall be initiated and resolved as described in section B5.

**Table B4-1 Laboratory Analytical Methods**

| Parameter | Method | Equipment Used | Estimated MDL * |
|---|---|---|---|
| Ammonia Nitrogen | EPA 350.1 | Perstorp Analytical Autoanalyzer | 0.037 mg/L |
| Nitrate-Nitrite Nitrogen | EPA 353.2 | Perstorp Analytical Autoanalyzer | 0.006 mg/L |
| Total Kjeldahl Nitrogen | EPA 351.1, 351.2 | Perstorp Analytical Autoanalyzer with Tecator block digester | 0.194 mg/L |
| Orthophosphate Phosphorus | EPA 365.2 | Bechman DU64 Spectrophotometer | 0.010 mg/L |
| Total Phosphorus | EPA 365.4, 365.2 | Perstorp Analytical Autoanalyzer with Tecator block digester | 0.101 mg/L |
| Total Suspended Solids | EPA 160.2 | Sartorius AC21P or Mettler AT261 Analytical Balance, Oven | 10 mg/L |
| Conductivity | EPA 120.1 | Platinum electrode, Hach conductivity meter, model 44600 | 2.0 μmhos/cm |
| Chemical Oxygen Demand | Hach 8000 | Hach DR 2000 | 6 mg/L |
| Azinphos (methyl)<br>Malathion<br>Parathion (methyl)<br>Prometryn | EPA 1657 | Thermionic Bead Nitrogen - Phosphorus Detector 5% carbowax packed primary with % carbowax Gas Chrom Q confirmation column | 0.009 μg/L<br>0.011 μg/L<br>0.018 μg/L<br>0.020 μg/L |
| Trifluralin<br>Permethrin (cis/trans)<br>Atrazine | EPA 1656 | Electron Capture Detector, DB-608 primary column with a DB1701 confirmation column | 0.05 μg/L<br>0.02 μg/L<br>0.50 μg/L |

* MDL - Method Detection Limit, redetermined periodically.
MDLs determined October 1996
Pesticide MDLs determined September 1996

Soil samples collected during this project will be analyzed by the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory in College Station, TX. There are no EPA approved methods for these sample matrices. Accepted procedures are listed in Table B4-2.

**Table B4-2 Soil Analytical Methods**

| Parameter | Method | Equipment Used | Estimated MDL[1] |
|---|---|---|---|
| Nitrate-nitrogen | Colorimeter, 410nm | TRAACS[2] | --- |
| Phosphorus | ICP[3,4] | Perkin-Elmer | --- |
| pH | Electometric | Orion Digital | 0.1 |
| Potassium | ICP | Perkin-Elmer or Spectro | --- |
| Calcium | ICP | Perkin-Elmer or Spectro | 10 ug/L |
| Magnesium | ICP | Perkin-Elmer or Spectro | 30 ug/L |
| Sodium | ICP | Perkin-Elmer or Spectro | 29 ug/L |
| Sulfate | ICP | Perkin-Elmer or Spectro | --- |
| Conductivity | Conductivity bridge | Horizon Ecology | N/A |

[1] MDL is the Method Detection Limit.
[2] TRAACS autoanalyzer by Braun and Luebe.
[3] ICP is Inductively Coupled Plasma Spectroscopy.
[4] Analysis of P using ICP has comparable results to colorimeter analysis, as per Donaho and Alto, 1992.

## Section B5: Quality Control Requirements

Samples shall be acquired using automated ISCO samplers with glass bottles and silicon tubing to assure integrity of pesticide analytes.

Data acceptance criteria shall be based upon precision and accuracy monitoring as described in Table B5-1. Method Detection Limit (MDL) estimates are listed in Table B4-1 above. MDLs are determined by analyzing a low level standard at 3-5 times the estimated MDL. This standard is analyzed 7 times using normal calibration and instrument operating conditions. The standard deviation of the 7 readings is determined and multiplied by 3.14 to obtain the MDL for the parameter of interest. Analytical precision shall be determined through the use of laboratory duplicate samples. For pesticides, matrix spikes (MS) and matrix spike duplicates (MSD) are used. The Percent Deviation is determined from the duplicate values. Sample matrix spiking, the addition of a known amount of the analyte of interest to a sample aliquot, is used to determine interferences present in the sample matrix. Accuracy is determined by percent recoveries of matrix spikes and of a Laboratory Control Sample (known spike of deionized water). Acceptance limits are listed in Table B5-1. In the event that a pesticide is detected in a sample from an unfamiliar site, the use of a secondary column analysis is required. This is a separate gas chromatographic column with different operating parameters used to confirm the presence of the pesticide. In the analysis of pesticides, surrogates standards are also added to all samples, calibration standards and method blanks. Surrogates are similar in chemical composition to the pesticides of interest, but are not likely to be present. This method shows that no pesticide loss occurs during sample preparation steps or GC operation. The use of method blanks, deionized water carried through all processes, will demonstrate that no contamination of samples occurs through laboratory handling or operation. Method blanks shall be used with every parameter in this project except conductivity and will be done on a 10% basis. Spikes and duplicate analyses will be performed will be done on a 10% basis for each set of samples collected..

In the event that a situation arises which may indicate a compromise of sample integrity or data quality, a Corrective Action Report (CAR) shall be initiated (Attachment A10-1). The person who first identifies the out-of-control situation shall initiate a Corrective Action by completing the first portion of the form and presenting it to his/her immediate supervisor. Out-of-control situations include, but are not limited to, automated stormwater sampler malfunction, broken sample bottles, missed holding times, instrument malfunction, improper preservation, or acceptance criteria for precision and accuracy not met. An attempt shall be made to correct the problem at the source level, supervisory levels, or the Project Manager may decide on what action to take if further action is deemed necessary. CARs initiated by TIAER Laboratory Manager will be included in TIAER's annual quality assurance report and will be available to project participants, upon request.

**Table B5-1 QC Acceptance Criteria**

| Parameter | Percent Deviation (PD) | Spike Recovery | Surrogate Used | Surrogate Recovery | LCS Recovery |
|---|---|---|---|---|---|
| Ammonia Nitrogen | 10% | 80-120% | NA | NA | 80-120% |
| Nitrate-Nitrite Nitrogen | 10% | 80-120% | NA | NA | 80-120% |
| Total Kjeldahl Nitrogen | 10% | 80-120% | NA | NA | 80-120% |
| Orthophosphate Phosphorus | 10% | 80-120% | NA | NA | 80-120% |
| Total Phosphorus | 10% | 80-120% | NA | NA | 80-120% |
| Total Suspended Solids | 10% | NA | NA | NA | 80-120% |
| Conductivity | 10% | NA | NA | NA | 80-120% |
| Chemical Oxygen Demand | 10% | 80-120% | NA | NA | 80-120% |
| Azinphos (methyl) | 10% | 37-127% | TBP, TPP | 40-120% | 83-119% |
| Malathion | 10% | 66-118% | TBP, TPP | 40-120% | 82-108% |
| Parathion (methyl) | 12% | 70-130% | TBP, TPP | 40-120% | 89-114% |
| Prometryn | 30% | 10-110% † | TBP, TPP | 40-120% | 70-130% |
| Atrazine | 20% | 31-132% | DBC | 40-120% | 70-130% |
| Trifluralin | 15% | 3-177% | DBC | 40-120% | 47-134% |
| Permethrin (cis) | 29% | 41-157% | DBC | 40-120% | 70-130% |
| Permethrin (trans) | 29% | 41-157% | DBC | 40-120% | 80-120% |

DBC= dibutyl chlorendate
TBP= tributyl phosphate
TPP= triphenyl phosphate
† Determined in the TIAER laboratory
Once matrix effects have been established for parameters, control charts will be used to establish more narrow acceptance criteria for LCS, duplicates and spikes.

## Section B7: Instrument Calibration and Frequency

Instruments and laboratory equipment used in the analyses of these samples are listed in table B4-1 above. All instruments are calibrated prior to use with the exception of the COD system which maintains a stored calibration curve and is functionally checked with a laboratory control standard prior to use. Calibration is normally performed with a 5 point standard curve. The exception is for conductivity which uses a two point LCS check for the platinum cell electrode. TSS also requires no standard other than class "S" weights used to check the balance. Stock standards are made from ACS certified materials where possible. Pesticides standards are made from NIST traceable sources. All certified standards are maintained traceable with certificates on file in the laboratory. Dilutions from all standards are recorded in the standards log book and given unique identification numbers. The date, analyst initials, stock sources with lot number and manufacturer, and how dilutions are made are also recorded in the standards log book. The flow meters used on the irrigated and dryland demonstration sites will be calibrated according to manufacturers directions.

All automatic sampling equipment will be inspected at least once every two weeks and serviced as needed. After a rainfall event, the ISCO samplers will be inspected within 24 hours to see if water samples have been collected. If the ISCO samplers properly collected water samples, then the samples will be transported to the TIAER laboratory for analysis.

## Section B9: Data Acquisition Requirements (Non-direct Measurements)

There is a weather station located on the irrigated demonstration site. This project will make use of weather data collected at this site as an input for the mathematical models. The mathematical models will determine the effectiveness of the BMPs in reducing edge-of-field loadings.

## Section C1: Assessments and Response Actions

The commitment to use approved equipment and approved methods when obtaining environmental samples and when producing field or laboratory measurements requires periodic verification that the equipment and methods are, in fact, being employed and being employed properly. This verification will be provided through an annual field performance audit performed by TSSWCB. Individual field personnel will be observed during the actual field investigation to verify that equipment and procedures are properly applied. If any problems are discovered in the monitoring procedures that would affect the quality of data collected at the demonstration sites than the problems will be addressed by the project participants and followed up with a Corrective Action Report. The TIAER laboratory will not undergo a performance audit by TSSWCB. The TIAER laboratory has an internal system of quality assurance and assessment to ensure the quality of data produced. Also, TNRCC and EPA may conduct a performance audit for this project.

All laboratory analyses will have the precision and accuracy of data determined on the particular day that the data were generated. Depending on the analysis, certain methodologies require that water blanks, standards, and reagent blanks be analyzed to verify that no instrument or chemical problem will affect the quality of the data. The specific requirements are presented in Section B5 of the QAPP.

To minimize downtime of all measurement systems, all field measurement and sampling equipment, and all laboratory equipment must be maintained in a working condition. Also, backup equipment or common spare parts will be available if any piece of equipment fails during use so that repairs or replacement can be made quickly and the measurement tasks resumed.

## Section C2: Reports to Management

The field measurement and sampling for the project will be done according to the QAPP. However, if the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. Corrective Action Reports will be filled out to document the problems and the remedial action taken. Laboratory CARs initiated by TIAER Laboratory Manager will be included in TIAER's annual quality assurance report and will be made available to project participants, upon request.

## Section D1: Data Review, Validation, and Verification

The project manager, laboratory manager and monitoring team personnel will be responsible for reviewing, validating, and verifying the measurement and sample data and the routine assessment of measurement procedures for precision and accuracy.

The Laboratory Manager shall be responsible for reviewing raw data produced by the TIAER laboratory. The Laboratory Manager shall check calculations on a 10% basis to verify that data is entered into the database correctly and be responsible for internal lab error corrections. Corrective Action Reports will be initiated in cases where invalid or incorrect data has been determined to have left the laboratory. Data outlier will be determined by constructing box plots and all data points that fall outside the inner fence will be considered outliers. The outliers will be checked for error in data transmission. Since most water quality data is not normally distributed, a natural log transformation on the data will be completed before construction of the box plots. Extreme outliers from the dataset (data points outside the outer fence) will be removed only if an error in data transmission can not be found. Nutrient data determined to be non-detected shall be reported as one-half the method detection limit. Pesticide data determined to be non-detected shall be reported as zero. The Quality Assurance Manager will review the project data prior to its usage in modeling and determination of BMP effectiveness for abnormalities or any unusual results. Any of these that occur will be traced back looking for sources of error. In the event no error is found, the data will be assumed normal and appropriate for decision determinations. If an error is found and cannot be resolved then the data will be discarded.

Whenever the procedures and guidelines established in this QAPP do not meet the specified levels of data quality, corrective actions will be required. Corrective action shall be initiated if variances from proper protocol are noted. Implementation of corrective actions will be the responsibility of the Quality Assurance Coordinator or the Laboratory Manager. Each manager may also initiate corrective action on his own initiative, if situations arise that require immediate attention. Documentation of any corrective action procedures through the Corrective Action Report (Attachment A10-1) will be provided by the appropriate manager, along with the results of implemented changes.

## Section D3: Reconciliation with Data Quality Objectives

Data completeness in this project will be relative to the number of stormwater and irrigation events sampled as compared to the number of proposed sampling events. Unforeseen weather conditions or equipment unreliability may reduce the number of events sampled. Accidents in handling, shipping, and laboratory analysis may also reduce the completeness of the sampling program. It will be the goal of this project to achieve 90% completeness in data collected. The validity of data collected will be analyzed using a t-test. However the data may need to be transformed using a natural log transformation since most water quality data contains unequal variances (variances that increase with the size of the mean). Nonparametric test such as the Wilcoxon test on median values could be used if there is a concern that the data does not meet the assumptions for parametric analysis even after transformation.

Representativeness and comparability of data, while unique to each individual collection site, is the responsibility of the Project Manager and the General Manager. By following the guidelines described in this QAPP, and through careful sampling design, the data collected in this project will be representative of the actual field conditions and comparable to similar applications. Representativeness and comparability of laboratory analyses is the responsibility of the Laboratory Manager.

The Project Manager will review the final data to ensure that it meets requirements as described in this QAPP.

## Section D3: Reconciliation with Data Quality Objectives

Data completeness in this project will be relative to the number of stormwater and irrigation events sampled as compared to the number of proposed sampling events. Unforeseen weather conditions or equipment unreliability may reduce the number of events sampled. Accidents in handling, shipping, and laboratory analysis may also reduce the completeness of the sampling program. It will be the goal of this project to achieve 90% completeness in data collected. The validity of data collected will be analyzed using a t-test. However the data may need to be transformed using a natural log transformation since most water quality data contains unequal variances (variances that increase with the size of the mean). Nonparametric test such as the Wilcoxon test on median values could be used if there is a concern that the data does not meet the assumptions for parametric analysis even after transformation.

Representativeness and comparability of data, while unique to each individual collection site, is the responsibility of the Project Manager and the General Manager. By following the guidelines described in this QAPP, and through careful sampling design, the data collected in this project will be representative of the actual field conditions and comparable to similar applications. Representativeness and comparability of laboratory analyses is the responsibility of the Laboratory Manager.

The Project Manager will review the final data to ensure that it meets requirements as described in this QAPP.

# APPENDIX D

## TIAER Laboratory Audit

| TEXAS STATE SOIL & WATER CONSERVATION BOARD | |
|---|---|
| **319 NPS PROJECT QUAPP AUDIT** | |
| | |
| **QA Inspector:** | Maria G. Pinto |
| **Project Name:** | Environmental Measurement Activities Relating to Arroyo Colorado NPS Project |
| **By:** | TAES, Southmost SWCD |
| | |
| **Location Visited:** | TIAER lab, Stephensville, TX |
| **Person Visited:** | Mark Murphy, Lab Manager |
| **Inspection Date:** | 9/30/96 |
| **Report Date:** | 10/08/96 |
| | |
| **Observations:** | A. Lab Conditions<br><br>Effective utility services and ideal environmental conditions such as proper lighting, ventilation, temperature and minimum noise levels were observed. Lab equipment was observed to be in good condition with thermometers where necessary (refrigerator and incubator) temperature log books are also kept by personnel, clean sinks and counters. Lab personnel is responsible for lab maintenance and warranties are always kept on expensive equipment. Lab safety is currently practiced: safety glasses, safety signs, emergency shower, etc. are available. The Lab uses standard "A" equipment. Since my last visit in November 1995, the lab has added a new piece of equipment that improves the data handling process, that is the PE Nelson 1022 which increases test results accuracy and might save up to half the time compared to the old method. This equipment is being used for the analysis of pesticides listed on the project's QAPP. The lab follows a QA/QC procedures manual approved by Mark Murphy (Lab Manager) and Nancy Easterling (Q/A Manager), approved SOP Manual, and *EPA-Methods for the Determination of Non conventional Pesticides in Municipal and Industrial Wastewater, EPA 821 RR-92-002.* The lab has improved the statistical analyses of the data by developing and incorporating a macro in the Microsoft excel spreadsheet software.<br><br>B. Testing, Lab Procedures, QC/QA<br><br>TSS, COD, Nitrate-Nitrite Nitrogen, Orthophosphate-Phosphorus, Ammonia Nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, Methyl Parathion, etc. as listed on *Table A7-1 Estimated Accuracy and Precision Limits of Measured Parameters* on p.14, rev. No. 1, are being analyzed at this location as mentioned in the project QAPP, except for Conductivity. It is a matter of concern whether such parameter needs to be determined at the Lab or out in the field, the QAPP needs to be corrected to show which processing agency is responsible for Conductivity.<br>All parameters are tested using the equipment and the EPA approved methods listed on *Table B4-1 Laboratory Analytical Methods* on p.28, QAPP revision No. 1, with the exception of COD which is determined by using the Hach 8000 instead of the Hach 2000, EPA method 410.4. The method used is equivalent to the EPA 410.4 listed on the Table B4-1. QA/QC is ensured by following QC requirement. The standard is analyzed 7 times using normal calibration every 6 months as instructed by the Lab Manager. Sample Matrix spiking is performed every 10 samples. Method blanks are used for every parameter and are done on a 10% basis. Log books are |

| | |
|---|---|
| | kept on every procedure. Additional practices such as always keeping ovens at right temperature, running blanks, preventing loose data sheets by recording data in log books, running duplicates at least every 10th sample to calculate deviation, using statistical methods to accept data are all QC practices followed by lab personnel.<br>The lab manger has expressed concern on the current sample handling procedures being followed by the contractor. The lab has received samples past the allowable preservation time, whether it is due to shipping, preservation or transfer of sample custody problems is yet to be investigated. The lab still analyzes such samples but the results are not being considered statistically. Corrective action report forms (CARs) are being utilized but are not being submitted every quarter as part of the project quarterly reports (which are not being submitted either) as stated on *Section A10: Documentation and Records* p. 17 rev. No.1, but annually, as part of an annual report. The CAR form displayed on p.18 is currently being used to document such actions. The lab follows Sample handling and custody procedures as stated on p. 25 revision No. 1 and uses the Chain of Custody form-Attachment B3-2, on p. 27.<br><br>C. Corrective Action<br><br>Another lab audit will be performed to ensure that current problems are corrected. Such problems to be addressed are:<br>1. Conductivity test - responsible agency<br>2. Quarterly reports - are not being turned in<br>3. Sample handling procedures by contractor - preservation times |
| | |

REVIEWED AND APPROVED BY

Byron Spoonts, TSSWCB Q/A OFFICER — DATE: 10-15-96

# APPENDIX E

## TIAER Laboratory Data from Monitoring

# Arroyo Colorado Monitoring Data

## Variable - *format:*

Site - *alpha numeric site designation (see abbreviations) 5.*
Sample # - *numeric 10.0*
Date - *mm/dd/yy*
Time - *hh:mm [military, central standard time ]*
NH3-N value - *numeric 8.4*
NH3-N remark - *alpha numeric*
NO2-N value - *numeric 6.3*
NO2-N remark - *alpha numeric*
NO3-N value - *numeric 7.3*
NO3-N remark - *alpha numeric*
TKN value - *numeric 6.2*
TKN remark - *alpha numeric*
PO4-P value - *numeric 6.3*
PO4-P remark - *alpha numeric*
TP value - *numeric 7.3*
TP remark - *alpha numeric*
TSS value - *numeric 8.2*
TSS remark - *alpha numeric*
COD value - *numeric 6.1*
COD remark - *alpha numeric*
Atrazine value - *numeric 8.3*
Atrazine remark - *alpha numeric*
Azinphos (methyl) value - *numeric 8.3*
Azinphos (methyl) remark - *alpha numeric*
Malathion value - *numeric 8.3*
Malathion remark - *alpha numeric*
Parathion (methyl) value - *numeric 8.3*
Parathion (methyl) remark - *alpha numeric*
Permethrin (cis/trans) value - *numeric 8.3*
Permethrin (cis/trans) remark - *alpha numeric*
Prometryn value - *numeric 8.3*
Prometryn remark - *alpha numeric*
Trifluralin value - *numeric 8.3*
Trifluralin remark - *alpha numeric*
Comments - *alpha numeric field containing general comments relating to the sample*

**NOTE**: For each constituent, a value field and a remark field is listed. The value field contains numeric concentration values. Missing data is denoted with a period (.). The remark field contains explanatory notes relating to the data point such as the method detection limit. When the analyte concentration was below the method detection limit (MDL) for the analytical procedure, the MDL is denoted in the remark column. One-half (1/2) the MDL was reported for concentration values for the following constituents: NH3-N, NO2-N, NO3-N, TKN, PO4-P, TP, TSS, COD. When pesticide concentrations were below the MDL, concentration values were reported as zero (0). If no concentration value is reported, the remark field usually contains an explanation for the missing data. If a quality assurance test fails for a group of samples, no value is assigned to the sample for the affected parameters. A period is entered into the value field and "est. < MDL" is entered into the remark field. When a reduced sample volume was used for a test, the associated MDL was doubled.

## Abbreviations and Reporting Units:

| Constituent | Abbreviation | Units Reported |
|---|---|---|
| Ammonia Nitrogen | NH3-N | mg/L |
| Nitrite Nitrogen | NO2-N | mg/L |
| Nitrate Nitrogen | NO3-N | mg/L |
| Total Kjeldahl Nitrogen | TKN | mg/L |
| Orthophosphate Phosphorus | PO4-P | mg/L |
| Total Phosphorus | TP | mg/L |
| Total Suspended Solids | TSS | mg/L |
| Chemical Oxygen Demand | COD | mg/L |
| Atrazine | ATRAZ | µg/L |
| Azinphos (methyl) | AZINP | µg/L |
| Malathion | MALAT | µg/L |
| Parathion (methyl) | PARAT | µg/L |
| Permethrin (cis/trans) | PERME | µg/L |
| Prometryn | PROME | µg/L |
| Trifluralin | TRIFL | µg/L |

Abbreviations
bmpdr = Dryland Site with BMP
condr = Dryland Site (Control, without BMP)
bmpir = Irrigated Site with BMP
conir = Irrigated Site (Control, without BMP)
HTEF = Holding time exceeded (field)
EST = Estimated value and/or quality control test(s) fail
IM = Instrument Malfunction
mg/L = milligram per liter
µg/L = microgram per liter
STAT = statistically close
ND = no detection, i.e., concentration is below method detection limit

C97-### or car97### - indicates the reference number (###) of the corrective action report submitted for the sample

## Inquiries:

If you have any questions regarding the data reported, please direct inquiries to one of the following individuals.


| | | | |
|---|---|---|---|
| Joan Flowers | (254) 968-9554 | flowers@tiaer.tarleton.edu | Project Manager |
| Nancy Easterling | (254) 968-9548 | easterl@tiaer.tarleton.edu | Quality Assurance Officer |
| Larry Hauck | (254) 968-9561 | hauck@tiaer.tarleton.edu | Project Administrator |


These data are also available in digital format by directing a written request to:

Texas Institute for Applied Environmental Research
Tarleton State University
Box T0410, Tarleton Station
Stephenville, Texas 76402
Attention: Joan Flowers
email: flowers@tiaer.tarleton.edu

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value mg/L | NH3-N remark | NO2-N value mg/L | NO2-N remark | NO3-N value mg/L | NO3-N remark | TKN value mg/L | TKN remark | PO4-P value mg/L | PO4-P remark | TP value mg/L | TP remark | TSS value mg/L | TSS remark | COD value mg/L | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0.09 | | 0.001 | <.002 | 0.42 | | 16.5 | | 0.36 | | 8.82 | | 8120 | | 204 | |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 0.1 | | 0.001 | <.002 | 0.11 | | 0.72 | | 0.39 | | 0.68 | | 162 | | 22 | |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0.12 | | 0.001 | <.002 | 0.1 | | 0.91 | | 0.38 | | 0.64 | | 86 | | 18 | |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 0.11 | | 0.001 | <.002 | 0.1 | | 0.9 | | 0.37 | | 0.64 | | 68 | | 22 | |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0.14 | | 0.001 | <.002 | 0.11 | | 0.9 | | 0.38 | | 0.69 | | 66 | | 16 | |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0.14 | | 0.001 | <.002 | 0.09 | | 0.93 | | 0.38 | | 0.74 | | 100 | | 8 | |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0.28 | | . | HTEF | . | HTEF | 15.8 | | . | HTEF | 8.12 | | 6260 | | 124 | |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0.15 | | . | HTEF | . | HTEF | 3.95 | | . | HTEF | 2.75 | | 1590 | | 42 | |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | 0.14 | | 0.008 | | 0.12 | | 8.71 | | 0.45 | | 4.44 | | 2500 | | 132 | |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | 0.15 | | 0.004 | | 0.06 | | 4.71 | | 0.42 | | 3.01 | | 1920 | | 68 | |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0.16 | | 0.005 | | 0.05 | | 2.26 | | 0.37 | | 1.6 | | 719 | | 26 | |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0.16 | | 0.006 | | 0.08 | | 4.58 | | 0.36 | | 2.81 | | 1950 | | 66 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 0.13 | | 0.004 | | 0.06 | | 1.9 | | 0.3 | | 1.28 | | 781 | | 21 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0.13 | | 0.003 | | 0.03 | | 1.77 | | 0.21 | | 0.96 | | 574 | | 15 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0.09 | | 0.001 | <.002 | 0.008 | <.015 | 0.91 | | 0.25 | | 0.57 | | 587 | | 6 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 0.53 | | 0.01 | | 0.08 | | 4.53 | | 0.52 | | 2.06 | | 1260 | | 11 | |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 0.08 | | 0.014 | | 0.08 | | 1.96 | | 0.27 | | 1.19 | | 726 | | 9 | |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 0.08 | | 0.011 | | 0.08 | | 1.21 | | 0.35 | | 0.75 | | 210 | | 8 | |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0.03 | | 0.005 | | 16.6 | | 0.7 | | 0.08 | | 0.055 | <.11 | 21 | | 36 | |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0.03 | | 0.005 | | 15.7 | | 0.84 | | 0.11 | | 0.055 | <.11 | 39 | | 23 | |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0.0075 | <.015 | 0.02 | | 13.2 | | 0.75 | | 0.08 | | 0.055 | <.11 | 18.7 | | 24 | |
| bmpir | 1000018439 | 5/14/96 | 6:00 | 0.11 | | 0.04 | | 11.6 | | 0.78 | | 0.06 | | 0.19 | | 17 | | 19 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | 0.31 | | 0.05 | | 12 | | 0.85 | | 0.06 | | 0.15 | | 5 | <10 | 15 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | 0.09 | | 0.02 | | 11.4 | | 1.02 | | 0.06 | | 0.14 | | 25 | | 18 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | 0.0075 | <.015 | 0.05 | | 12.9 | | 0.81 | | 0.06 | | 1.21 | | 26 | | 19 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | 0.06 | | 0.05 | | 13 | | 1.09 | | 0.07 | | 0.17 | | 32 | | 21 | |
| bmpir | 1000018444 | 5/15/96 | 6:00 | 0.0075 | <.015 | 0.03 | | 12.8 | | 0.84 | | 0.07 | | 0.055 | <.11 | 14 | | 18 | |
| bmpir | 1000018445 | 5/15/96 | 12:00 | 0.0075 | <.015 | 0.02 | | 13.8 | | 0.98 | | 0.08 | | 0.11 | | 17 | | 20 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | 0.0075 | <.015 | 0.018 | | 13.5 | | 0.51 | | 0.07 | | 0.16 | | 12 | | 22 | |
| bmpir | 1000018452 | 5/16/96 | 0:00 | 0.0075 | <.015 | 0.004 | | 13.2 | | 0.46 | | 0.07 | | 0.14 | | 12 | | 20 | |
| bmpir | 1000018453 | 5/16/96 | 6:00 | 0.0075 | <.015 | 0.004 | | 13.2 | | 0.55 | | 0.07 | | 0.055 | <.11 | 84 | | 18 | |
| bmpir | 1000018454 | 5/16/96 | 12:00 | 0.0075 | <.015 | 0.009 | | 12.7 | | 0.7 | | 0.06 | | 0.055 | <.11 | 11 | | 16 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.46 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 19 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | 0.05 | | . | HTEF | . | HTEF | 0.53 | | . | HTEF | 0.055 | <.11 | 11 | | 26 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | 0.06 | | . | HTEF | . | HTEF | 0.36 | | . | HTEF | 0.055 | <.11 | 20 | | 16 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.7 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 16 | |

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.47 | | . | HTEF | 0.055 | <.11 | 10 | | 21 | |
| bmpir | 1000018460 | 5/18/96 | 0:00 | 0.0075 | <.015 | 0.003 | | 11.4 | | 0.67 | | 0.07 | | 0.11 | | 12 | | 21 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | 0.0075 | <.015 | 0.006 | | 11.5 | | 0.54 | | 0.07 | | 0.055 | <.11 | 19 | | 21 | |
| bmpir | 1000019617 | 6/24/96 | 17:00 | 1.03 | | 0.001 | <.002 | 0.3 | | 2.18 | | 0.07 | | 0.24 | | 43 | | 12 | |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 0.12 | | . | HTEF | . | HTEF | 0.99 | | . | HTEF | 0.33 | | 52 | | 32 | |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 0.1 | | . | HTEF | . | HTEF | 1.08 | | . | HTEF | 0.22 | | 19 | | 24 | |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 0.12 | | 0.014 | | 2.69 | | 1.07 | | 0.05 | | 0.2 | | 53 | | 23 | |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 0.12 | | 0.01 | | 2.47 | | 1.15 | | 0.05 | | 0.21 | | 11 | | 17 | |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 0.16 | | 0.08 | | 3.21 | | 1.28 | | 0.04 | | 0.2 | | 35 | | 21 | |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 0.11 | | 0.04 | | 3.26 | | 1.09 | | 0.05 | | 0.23 | | 18 | | 20 | |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 0.11 | | . | HTEF | . | HTEF | 0.91 | | . | HTEF | 0.16 | | 19 | | 15 | |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0.11 | | 0.001 | <.002 | 4.36 | | 0.77 | | 0.09 | | 0.14 | | 10 | | 15 | |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0.12 | | 0.001 | <.002 | 4.58 | | 0.86 | | 0.09 | | 0.13 | | 5 | <10 | 15 | |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0.13 | | . | HTEF | . | HTEF | 0.78 | | . | HTEF | 0.13 | | 26 | | 11 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0.07 | | . | HTEF | . | HTEF | 0.53 | | . | HTEF | 0.16 | | 14 | | 17 | |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0.06 | | . | HTEF | . | HTEF | 0.79 | | . | HTEF | 0.13 | | 10 | | 13 | |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0.07 | | 0.08 | | 0.008 | <.015 | 0.89 | | 4.17 | | 0.055 | <.11 | 14 | | 13 | |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 0.08 | | 0.04 | | 4.56 | | 0.69 | | 0.08 | | 0.13 | | 16 | | 15 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 0.05 | | 0.03 | | 4.71 | | 0.69 | | 0.08 | | 0.12 | | 18 | | 19 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | 0.14 | | 0.017 | | 4.72 | | 0.74 | | 0.08 | | 0.11 | | 11 | | 18 | |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 0.06 | | 0.001 | <.002 | 4.54 | | 0.67 | | 0.09 | | 0.055 | <.11 | 12 | | 20 | |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 0.11 | | 0.001 | <.002 | 4.47 | | 0.86 | | 0.08 | | 0.24 | | 24 | | 9 | |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 0.09 | | 0.001 | <.002 | 4.55 | | 0.76 | | 0.09 | | 0.19 | | 14 | | 10 | |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 0.1 | | 0.002 | | 4.32 | | 0.73 | | 0.09 | | 0.18 | | 28 | | 9 | |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 0.0075 | <.015 | 0.004 | | 4.41 | | 0.94 | | 0.08 | | 0.055 | <.11 | 24 | | 13 | |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 0.0075 | <.015 | 0.004 | | 4.48 | | 0.66 | | 0.08 | | 0.055 | <.11 | 21 | | 17 | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 0.05 | | 0.003 | | 4.49 | | 0.68 | | 0.08 | | 0.055 | <.11 | 15 | | 14 | |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 0.16 | | 0.012 | | 3.98 | | 1.07 | | 0.08 | | 0.055 | <.11 | 27 | | 13 | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 0.1 | | 0.001 | <.002 | 5.98 | | 1.32 | | 0.07 | | 0.26 | | 29 | | 22 | |
| bmpir | 1000021090 | 8/26/96 | 22:00 | . | EST .72 | 0.001 | <.002 | 5.75 | | 0.96 | | 0.08 | | 0.21 | | 16 | | 20 | |
| bmpir | 1000021091 | 8/27/96 | 2:00 | . | EST .56 | 0.001 | <.002 | 5.69 | | 0.81 | | 0.09 | | 0.17 | | 11 | | 24 | |
| bmpir | 1000021092 | 8/27/96 | 6:00 | . | EST .64 | 0.001 | <.002 | 5.57 | | 0.94 | | 0.08 | | 0.17 | | 16 | | 22 | |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0.47 | | 0.001 | <.002 | 5.82 | | 0.96 | | 0.08 | | 0.12 | | 16 | | 15 | |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0.61 | | 0.001 | <.002 | 5.43 | | 0.9 | | 0.17 | | 0.055 | <.11 | 12 | | 17 | |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 0.12 | | 0.001 | <.002 | 6.22 | | 0.63 | | 0.07 | | 0.17 | | 11 | | 20 | |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 0.3 | | 0.001 | <.002 | 6.32 | | 0.67 | | 0.08 | | 0.18 | | 15 | | 21 | |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 0.17 | | 0.001 | <.002 | 5.86 | | 0.65 | | 0.07 | | 0.13 | | 5 | <10 | 21 | |

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0.16 | | 0.001 | <.002 | 5.97 | | 0.75 | | 0.07 | | 0.12 | | 5 | <10 | 21 | |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0.12 | | 0.001 | <.002 | 5.6 | | 0.88 | | 0.08 | | 0.12 | | 5 | <10 | 21 | |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0.45 | | 0.001 | <.002 | 5.64 | | 0.88 | | 0.08 | | 0.2 | | 5 | <10 | 22 | |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0.07 | | 0.011 | | 4.61 | | 0.57 | | 0.08 | | 0.12 | | 25 | | 25 | |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0.09 | | 0.011 | | 5.05 | | 0.7 | | 0.08 | | 0.13 | | 14 | | 23 | |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0.09 | | 0.008 | | 4.89 | | 0.77 | | 0.08 | | 0.055 | <.11 | 15 | | 22 | |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0.08 | | 0.011 | | 5.08 | | 0.43 | | 0.08 | | 0.055 | <.11 | 16 | | 22 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0.08 | | 0.018 | | 5.15 | | 0.43 | | 0.08 | | 0.26 | | 5 | <10 | 19 | |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0.14 | | 0.011 | | 5.29 | | 0.44 | | 0.09 | | 0.28 | | 11 | | 18 | |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 0.03 | | . | HTEF | . | HTEF | 1 | | . | HTEF | 0.28 | | 19 | | 17 | |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 0.03 | | . | HTEF | . | HTEF | 0.99 | | . | HTEF | 0.18 | | 16 | | 17 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0.04 | | . | HTEF | . | HTEF | 0.77 | | . | HTEF | 0.15 | | 5 | <10 | 16 | |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0.05 | | . | HTEF | . | HTEF | 0.73 | | . | HTEF | 0.13 | | 26 | | 13 | |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0.1 | | 0.04 | | 4.27 | | 0.71 | | 0.07 | | 0.14 | | 32 | | 17 | |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 0.08 | | 0.04 | | 4.78 | | 0.87 | | 0.09 | | 0.051 | <.101 | 12 | | 12 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 0.11 | | 0.04 | | 5.1 | | 0.79 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 11 | |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 0.1 | | 0.04 | | 5.52 | | 0.62 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 10 | |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 0.15 | | 0.03 | | 5.12 | | 0.53 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 9 | |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 0.09 | | 0.03 | | 4.62 | | 0.73 | | 0.09 | | 0.051 | <.101 | 5 | <10 | 7 | |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 0.06 | | 0.05 | | 5.89 | | 1.2 | | 0.07 | | 0.19 | | 5 | <10 | 17 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 0.07 | | 0.06 | | 5.95 | | 1.22 | | 0.09 | | 0.14 | | 10 | | 19 | |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0.06 | | 0.05 | | 6.22 | | 1.31 | | 0.08 | | 0.13 | | 5 | <10 | 20 | |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0.05 | | 0.05 | | 6 | | 1.25 | | 0.08 | | 0.15 | | 5 | <10 | 16 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0.0185 | <.037 | 0.05 | | 5.9 | | 0.69 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 12 | |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0.06 | | 0.05 | | 5.93 | | 0.72 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 1.08 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 15 | |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 1.57 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 0.0185 | <.037 | . | HTEF | . | HTEF | 0.89 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 0.04 | | . | HTEF | . | HTEF | 0.82 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 0.04 | | . | HTEF | . | HTEF | 0.86 | | . | HTEF | 0.051 | <.101 | 5 | <10 | 19 | |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 0.05 | | 0.05 | | 6.03 | | 0.87 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 0.04 | | 0.05 | | 6.08 | | 0.81 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 16 | |
| bmpir | 1000026469 | 2/4/97 | 0:00 | 0.0185 | <.037 | 0.05 | | 6.05 | | 0.78 | | 0.16 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 0.04 | | 0.05 | | 5.84 | | 0.84 | | 0.13 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 0.05 | | 0.05 | | 5.8 | | 0.66 | | 0.14 | | 0.051 | <.101 | 5 | <10 | 17 | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0.07 | | . | car97201 | . | car97201 | 1.17 | | . | car97201 | 0.039 | <.077 | 22 | | 11 | |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0.05 | | . | car97201 | . | car97201 | 1.08 | | . | car97201 | 0.1 | STAT | 14 | | 2 | <4 |

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0.07 | | . | car97201 | . | car97201 | 1.21 | | . | car97201 | 0.08 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0.09 | | . | car97201 | . | car97201 | 0.76 | | . | car97201 | 0.34 | | . | C97-203 | 2 | <4 |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0.14 | | . | car97201 | . | car97201 | 0.77 | | . | car97201 | 0.28 | | . | C97-203 | 2 | <4 |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0.05 | | . | car97201 | . | car97201 | 0.67 | | . | car97201 | 0.26 | | 5 | <10 | 9 | |
| bmpir | 1000032693 | 6/14/97 | 22:00 | 0.07 | | 0.011 | | 6.04 | | 0.59 | | 0.11 | | 0.16 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032694 | 6/15/97 | 2:00 | 0.04 | | 0.006 | | 5.88 | | 0.57 | | 0.13 | | 0.15 | | 16 | | 5 | |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 0.05 | | 0.007 | | 6.01 | | 0.69 | | 0.11 | | 0.14 | | 5 | <10 | 4 | |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 0.08 | | 0.014 | | 4.9 | | 0.76 | | 0.1 | | 0.29 | | 5 | <10 | 2 | <4 |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 0.18 | | 0.01 | | 5.31 | | 0.88 | | 0.11 | | 0.45 | | 5 | <10 | 9 | |
| condr | 1000021630 | 8/31/96 | 16:00 | 0.11 | | 0.001 | <.002 | 0.77 | | 25.2 | | 0.39 | | 10.5 | | 11700 | | 380 | |
| condr | 1000023112 | 9/27/96 | 23:00 | 0.31 | | . | HTEF | . | HTEF | 17.2 | | . | HTEF | 5.48 | | 5760 | | 117 | |
| condr | 1000023113 | 9/28/96 | 1:00 | 0.15 | | . | HTEF | . | HTEF | 4.9 | | . | HTEF | 2.48 | | 1660 | | 53 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 0.64 | | 0.006 | | 0.11 | | 7.6 | | 0.37 | | 3.83 | | 3050 | | 108 | |
| condr | 1000023175 | 10/5/96 | 2:00 | 0.2 | | 0.006 | | 0.1 | | 4.45 | | 0.37 | | 2.5 | | 1760 | | 55 | |
| condr | 1000023176 | 10/5/96 | 4:00 | 0.16 | | 0.005 | | 0.06 | | 3.67 | | 0.45 | | 2.22 | | 1600 | | 54 | |
| condr | 1000023177 | 10/5/96 | 6:00 | 0.16 | | 0.004 | | 0.06 | | 1.81 | | 0.39 | | 1.25 | | 471 | | 16 | |
| condr | 1000023178 | 10/5/96 | 8:00 | 0.15 | | 0.004 | | 0.06 | | 1.89 | | 0.35 | | 1.02 | | 593 | | 8 | |
| condr | 1000023179 | 10/5/96 | 10:00 | 0.13 | | 0.001 | <.002 | 0.05 | | 1.46 | | 0.27 | | 0.98 | | 626 | | 20 | |
| condr | 1000023189 | 10/5/96 | 20:00 | 0.13 | | 0.001 | <.002 | 0.018 | | 0.47 | | 0.21 | | 0.29 | | 70 | | 2.5 | <5 |
| condr | 1000023190 | 10/6/96 | 0:00 | 0.09 | | 0.001 | <.002 | 0.02 | | 0.59 | | 0.23 | | 0.35 | | 110 | | 2.5 | <5 |
| condr | 1000023191 | 10/6/96 | 4:00 | 0.09 | | 0.001 | <.002 | 0.016 | | 0.51 | | 0.23 | | 0.31 | | 35 | | 2.5 | <5 |
| condr | 1000029148 | 3/11/97 | 8:00 | 0.19 | | 0.02 | | 0.18 | | 3.77 | | 0.38 | | 2.08 | | 1540 | | 13 | |
| conir | 1000018214 | 4/16/96 | 4:00 | 0.04 | | 0.015 | | 15.7 | | 0.63 | | 0.07 | | 0.055 | <.11 | 74 | | 36 | |
| conir | 1000018213 | 4/16/96 | 16:00 | 0.06 | | 0.04 | | 16.4 | | 0.91 | | 0.07 | | 0.13 | | 197 | | 30 | |
| conir | 1000018215 | 4/17/96 | 4:00 | 0.17 | | 0.001 | <.002 | 16 | | 0.74 | | 0.08 | | 0.18 | | 176 | | 27 | |
| conir | 1000018455 | 5/16/96 | 0:00 | 0.0075 | <.015 | 0.003 | | 13.6 | | 0.84 | | 0.08 | | 0.2 | | 119 | | 20 | |
| conir | 1000018456 | 5/16/96 | 3:00 | 0.0075 | <.015 | 0.004 | | 13.4 | | 0.65 | | 0.07 | | 0.16 | | 60 | | 20 | |
| conir | 1000018457 | 5/16/96 | 6:00 | 0.0075 | <.015 | 0.002 | | 13.2 | | 0.98 | | 0.08 | | 0.11 | | 31 | | 20 | |
| conir | 1000018458 | 5/16/96 | 12:00 | 0.0075 | <.015 | 0.002 | | 12.6 | | 0.67 | | 0.08 | | 0.055 | <.11 | 40 | | 16 | |
| conir | 1000018469 | 5/16/96 | 18:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.42 | | . | HTEF | 0.14 | | 16 | | 16 | |
| conir | 1000018470 | 5/17/96 | 0:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.34 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 21 | |
| conir | 1000018471 | 5/17/96 | 6:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.63 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 22 | |
| conir | 1000018472 | 5/17/96 | 12:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 0.43 | | . | HTEF | 0.055 | <.11 | 10 | | 21 | |
| conir | 1000018462 | 5/17/96 | 18:00 | 0.04 | | . | HTEF | . | HTEF | 0.79 | | . | HTEF | 0.14 | | 27 | | 23 | |
| conir | 1000018463 | 5/18/96 | 0:00 | 0.02 | | 0.07 | | 12.5 | | 0.6 | | 0.09 | | 0.12 | | 14 | | 20 | |
| conir | 1000018464 | 5/18/96 | 12:00 | 0.0075 | <.015 | 0.003 | | 14.1 | | 0.46 | | 0.07 | | 0.055 | <.11 | 13 | | 20 | |
| conir | 1000018473 | 5/18/96 | 18:00 | 0.0075 | <.015 | 0.003 | | 11.7 | | 0.61 | | 0.07 | | 0.055 | <.11 | 14 | | 34 | |

Results of Water Quality Monito..g - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 2.81 | | 0.07 | | 1.35 | | 4.4 | | 0.06 | | 0.29 | | 81 | | 19 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 1.67 | | 0.09 | | 1.92 | | 3.11 | | 0.09 | | 0.2 | | 56 | | 12 | |
| conir | 1000020859 | 8/18/96 | 23:00 | 1.03 | | 0.019 | | 2.8 | | 2.05 | | 0.08 | | 0.17 | | 16 | | 13 | |
| conir | 1000020860 | 8/19/96 | 2:00 | 0.74 | | 0.014 | | 3.12 | | 1.68 | | 0.08 | | 0.17 | | 5 | <10 | 14 | |
| conir | 1000020861 | 8/19/96 | 8:00 | 0.32 | | 0.008 | | 3.58 | | 1.28 | | 0.07 | | 0.14 | | 5 | <10 | 10 | |
| conir | 1000020862 | 8/19/96 | 14:00 | 0.1 | | 0.003 | | 3.52 | | 0.88 | | 0.06 | | 0.22 | | 14 | | 11 | |
| conir | 1000020947 | 8/19/96 | 20:00 | 0.07 | | 0.006 | | 3.2 | | 0.85 | | 0.06 | | 0.055 | <.11 | 19 | | 10 | |
| conir | 1000020948 | 8/20/96 | 2:00 | 0.06 | | 0.006 | | 3.03 | | 0.93 | | 0.06 | | 0.14 | | 5 | <10 | 11 | |
| conir | 1000020949 | 8/20/96 | 8:00 | 0.37 | | 0.019 | | 2.66 | | 1.54 | | 0.06 | | 0.055 | <.11 | 14 | | 11 | |
| conir | 1000020950 | 8/20/96 | 14:00 | 0.06 | | 0.009 | | 2.85 | | 0.57 | | 0.06 | | 0.055 | <.11 | 12 | | 11 | |
| conir | 1000020966 | 8/20/96 | 20:00 | 0.04 | | 0.001 | <.002 | 2.78 | | 0.6 | | 0.07 | | 0.055 | <.11 | 5 | <10 | 16 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0.11 | | 0.001 | <.002 | 2.75 | | 0.59 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 14 | |
| conir | 1000020968 | 8/21/96 | 8:00 | 0.06 | | 0.001 | <.002 | 2.79 | | 0.91 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 18 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0.06 | | 0.001 | <.002 | 2.82 | | 0.92 | | 0.06 | | 0.055 | <.11 | 5 | <10 | 12 | |
| conir | 1000021095 | 8/26/96 | 18:00 | 0.54 | | 0.001 | <.002 | 6.41 | | 1.13 | | 0.2 | | 0.18 | | 86 | | 11 | |
| conir | 1000021096 | 8/26/96 | 22:00 | 0.51 | | 0.001 | <.002 | 6.31 | | 1.01 | | 0.21 | | 0.19 | | 18 | | 20 | |
| conir | 1000021097 | 8/27/96 | 2:00 | 0.34 | | 0.001 | <.002 | 6.11 | | 0.9 | | 0.18 | | 0.27 | | 12 | | 18 | |
| conir | 1000021098 | 8/27/96 | 6:00 | 0.25 | | 0.001 | <.002 | 6.16 | | 0.98 | | 0.08 | | 0.24 | | 16 | | 20 | |
| conir | 1000021099 | 8/27/96 | 10:00 | 0.13 | | 0.001 | <.002 | 6 | | 0.76 | | 0.09 | | 0.2 | | 5 | <10 | 21 | |
| conir | 1000021100 | 8/27/96 | 14:00 | 0.27 | | 0.07 | | 5.5 | | 1 | | 0.09 | | 0.17 | | 11 | | 21 | |
| conir | 1000021141 | 8/27/96 | 18:00 | 0.17 | | 0.001 | <.002 | 5.28 | | 0.78 | | 0.08 | | 0.14 | | 11 | | 20 | |
| conir | 1000021142 | 8/27/96 | 22:00 | 0.17 | | 0.001 | <.002 | 5.19 | | 0.86 | | 0.08 | | 0.055 | <.11 | 5 | <10 | 22 | |
| conir | 1000021143 | 8/28/96 | 2:00 | 0.08 | | 0.001 | <.002 | 5.02 | | 0.63 | | 0.08 | | 0.055 | <.11 | 5 | <10 | 18 | |
| conir | 1000021144 | 8/28/96 | 6:00 | 0.14 | | 0.001 | <.002 | 5.33 | | 0.65 | | 0.08 | | 0.055 | <.11 | 36 | | 18 | |
| conir | 1000021145 | 8/28/96 | 10:00 | 0.1 | | 0.001 | <.002 | 5.13 | | 0.6 | | 0.08 | | 0.055 | <.11 | 16 | | 18 | |
| conir | 1000021146 | 8/28/96 | 14:00 | 0.0075 | <.015 | 0.001 | <.002 | 5.05 | | 0.71 | | 0.08 | | 0.055 | <.11 | 12 | | 23 | |
| conir | 1000021306 | 8/28/96 | 18:00 | 0.11 | | 0.014 | | 5.94 | | 0.59 | | 0.07 | | 0.27 | | 5 | <10 | 23 | |
| conir | 1000021307 | 8/28/96 | 22:00 | 0.14 | | 0.014 | | 5.79 | | 0.78 | | 0.07 | | 0.22 | | 24 | | 25 | |
| conir | 1000021308 | 8/29/96 | 2:00 | 0.12 | | 0.011 | | 5.45 | | 0.34 | | 0.08 | | 0.17 | | 5 | <10 | 22 | |
| conir | 1000021309 | 8/29/96 | 6:00 | 0.09 | | 0.008 | | 5.75 | | 0.9 | | 0.08 | | 0.15 | | 5 | <10 | 22 | |
| conir | 1000021310 | 8/29/96 | 10:00 | 0.12 | | 0.011 | | 5.89 | | 0.41 | | 0.08 | | 0.13 | | 5 | <10 | 20 | |
| conir | 1000021311 | 8/29/96 | 14:00 | 0.11 | | 0.011 | | 5.42 | | 0.47 | | 0.08 | | 0.13 | | 5 | <10 | 21 | |
| conir | 1000021637 | 8/29/96 | 20:00 | 0.03 | | . | HTEF | . | HTEF | 0.85 | | . | HTEF | 0.12 | | 5 | <10 | 15 | |
| conir | 1000021638 | 8/30/96 | 2:00 | 0.02 | | . | HTEF | . | HTEF | 1.03 | | . | HTEF | 0.055 | <.11 | 5 | <10 | 17 | |
| conir | 1000021639 | 8/30/96 | 8:00 | 0.018 | | . | HTEF | . | HTEF | 0.85 | | . | HTEF | 0.15 | | 5 | <10 | 18 | |
| conir | 1000021640 | 8/30/96 | 14:00 | 0.0075 | <.015 | . | HTEF | . | HTEF | 1.14 | | . | HTEF | 0.15 | | 16 | | 16 | |
| conir | 1000026427 | 1/29/97 | 18:00 | 0.09 | | 0.13 | | 5.43 | | 1.76 | | 0.13 | | 0.73 | | 490 | | 31 | |

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

| Site | Sample # | Date | Time | NH3-N value | NH3-N remark | NO2-N value | NO2-N remark | NO3-N value | NO3-N remark | TKN value | TKN remark | PO4-P value | PO4-P remark | TP value | TP remark | TSS value | TSS remark | COD value | COD remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0.1 | | 0.11 | | 5.15 | | 1.28 | | 0.1 | | 0.33 | | 198 | | 13 | |
| conir | 1000026429 | 1/30/97 | 2:00 | 0.09 | | 0.1 | | 6.38 | | 1.27 | | 0.12 | | 0.27 | | 156 | | 14 | |
| conir | 1000026430 | 1/30/97 | 6:00 | 0.07 | | 0.12 | | 5.9 | | 1.5 | | 0.26 | | 0.25 | STAT | 137 | | 13 | |
| conir | 1000026431 | 1/30/97 | 10:00 | 0.06 | | 0.12 | | 6.57 | | 1.57 | | 0.12 | | 0.24 | | 126 | | 29 | |
| conir | 1000026432 | 1/30/97 | 14:00 | 0.05 | | 0.11 | | 6.45 | | 1.45 | | 0.12 | | 0.24 | | 119 | | 12 | |
| conir | 1000026434 | 1/30/97 | 18:00 | 0.0185 | <.037 | 0.08 | | 5.25 | | 1.42 | | 0.09 | | 0.37 | | 330 | | 16 | |
| conir | 1000026435 | 1/30/97 | 22:00 | 0.11 | | 0.07 | | 4.38 | | 1.38 | | 0.1 | | 0.31 | | 207 | | 14 | |
| conir | 1000026436 | 1/31/97 | 2:00 | 0.1 | | 0.06 | | 5.67 | | 1.09 | | 0.1 | | 0.6 | | 515 | | 15 | |
| conir | 1000026437 | 1/31/97 | 6:00 | 0.16 | | 0.05 | | 5.74 | | 1.38 | | 0.1 | | 0.44 | | 356 | | 12 | |
| conir | 1000026438 | 1/31/97 | 10:00 | 0.11 | | 0.04 | | 5.31 | | 0.9 | | 0.1 | | 0.28 | | 205 | | 13 | |
| conir | 1000026439 | 1/31/97 | 14:00 | 0.13 | | 0.04 | | 5.3 | | 0.84 | | 0.1 | | 0.46 | | 438 | | 10 | |
| conir | 1000026446 | 1/31/97 | 18:00 | 0.09 | | 0.03 | | 4.63 | | 0.77 | | 0.08 | | 0.24 | | 251 | | 19 | |
| conir | 1000026447 | 1/31/97 | 22:00 | 0.09 | | 0.03 | | 4.39 | | 1.39 | | 0.09 | | 0.19 | | 114 | | 25 | |
| conir | 1000026448 | 2/1/97 | 2:00 | 0.12 | | 0.03 | | 4.41 | | 1.44 | | 0.09 | | 0.34 | | 245 | | 22 | |
| conir | 1000026449 | 2/1/97 | 6:00 | 0.1 | | 0.03 | | 5.33 | | 1.52 | | 0.09 | | 0.35 | | 226 | | 19 | |
| conir | 1000026450 | 2/1/97 | 10:00 | 0.09 | | 0.05 | | 6.46 | | 1.41 | | 0.08 | | 0.29 | | 107 | | 20 | |
| conir | 1000026451 | 2/1/97 | 14:00 | 0.11 | | 0.05 | | 6.84 | | 1.27 | | 0.1 | | 0.19 | | 69 | | 19 | |
| conir | 1000026458 | 2/1/97 | 18:00 | 0.0185 | <.037 | 0.05 | | 7.1 | | 0.92 | | 0.08 | | 0.051 | <.101 | 14 | | 16 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 0.04 | | 0.04 | | 7.06 | | 1 | | 0.08 | | 0.051 | <.101 | 22 | | 17 | |
| conir | 1000026460 | 2/2/97 | 6:00 | 0.08 | | 0.04 | | 7.35 | | 0.95 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 18 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0.0185 | <.037 | 0.04 | | 7.38 | | 0.97 | | 0.08 | | 0.051 | <.101 | 5 | <10 | 18 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0.11 | | . | car97201 | . | car97201 | 0.82 | | . | car97201 | 0.29 | | 13 | | 9 | |
| conir | 1000032690 | 6/14/97 | 6:00 | 0.07 | | . | car97201 | . | car97201 | 0.71 | | . | car97201 | 0.25 | STAT | 45 | | 12 | |
| conir | 1000032691 | 6/14/97 | 10:00 | 0.06 | | . | car97201 | . | car97201 | 0.79 | | . | car97201 | 0.16 | | 12 | | 2 | <4 |
| conir | 1000032698 | 6/14/97 | 14:00 | 0.36 | | 0.03 | | 5.28 | | 1.18 | | 0.1 | | 0.38 | | 5 | <10 | 6 | |
| conir | 1000032699 | 6/14/97 | 18:00 | 0.09 | | 0.011 | | 7.45 | | 0.93 | | 0.11 | | 0.39 | | 48 | | 2 | <4 |
| conir | 1000032700 | 6/14/97 | 22:00 | 0.1 | | 0.017 | | 7.4 | | 0.86 | | 0.11 | | 0.4 | | 90 | | 7 | |
| conir | 1000032701 | 6/15/97 | 10:00 | 0.1 | | 0.008 | | 7.18 | | 0.81 | | 0.12 | | 0.32 | | 44 | | 4 | |

Results of Water Quality Monito g - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | µg/L | | µg/L | | µg/L | | µg/L | | µg/L | |
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 1.087 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0.638 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 1.18 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0.522 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0 | <1.00 | 0 | <.009 | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0 | <.5 | 0 | <.009 | 0.016 | | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0 | <.5 | 0 | <.009 | 0.016 | | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | 0 | <.5 | . | EST<.009 | . | EST<.011 | . | EST<.018 | 0 | <.2 |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | 1.056 | | . | EST<.018 | . | EST<.022 | . | EST<.036 | 0 | <.4 |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0.994 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0 | <.5 | 0.055 | | 0.016 | | 0.019 | | 0.506 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 2.063 | | 0 | <.009 | 0.014 | | 0 | <.018 | 0.548 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0.912 | | 0 | <.009 | 0.016 | | 0 | <.018 | 0.5 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.478 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 1.45 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 10.8 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 6.33 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0 | <.86 | 0 | <.016 | 0 | <.019 | 0 | <.031 | 0 | <.34 |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000018439 | 5/14/96 | 6:00 | 5.94 | | 0 | <.018 | 0 | <.022 | . | IM | 1.1 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | 7.76 | | 0 | <.009 | 0 | <.011 | . | IM | 2.04 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | 4.69 | | 0 | <.009 | 0 | <.011 | . | IM | 1.05 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | 2.77 | | 0 | <.009 | 0 | <.011 | . | IM | 1.24 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | 2.77 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018444 | 5/15/96 | 6:00 | 1.18 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018445 | 5/15/96 | 12:00 | 1.06 | | 0 | <.009 | 0 | <.011 | . | IM | 0.96 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | 4.85 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018452 | 5/16/96 | 0:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018453 | 5/16/96 | 6:00 | 0 | <1.0 | 0 | <.018 | 0 | <.022 | . | IM | 0 | <.4 |
| bmpir | 1000018454 | 5/16/96 | 12:00 | 9.11 | | 0 | <.018 | 0 | <.022 | . | IM | 1.12 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | 1.18 | | 0 | <.018 | 0 | <.022 | . | IM | 1.17 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | 1.4 | | 0 | <.009 | 0 | <.011 | . | IM | 2.7 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | 1.63 | | 0 | <.009 | 0 | <.011 | . | IM | 1.16 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | 1.56 | | 0 | <.009 | 0 | <.011 | . | IM | 1.98 | |

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000018460 | 5/18/96 | 0:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| bmpir | 1000019617 | 6/24/96 | 17:00 | 0 | <1.0 | 0 | <.018 | 0 | <.022 | 0 | <.2 | 0 | <0.4 |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 11.4 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 6.44 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 3.2 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 2.27 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 5.93 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 5.17 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 1 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0.645 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0.552 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0 | 1 | 0 | <0.018 | 0 | <0.022 | 0 | <0.036 | 0.222 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0 | <.50 | 0.298 | | 0 | <0.011 | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0 | <.50 | 0 | <0.009 | 0.028 | | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0 | <.50 | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | 0.2 |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 3.95 | | 0 | <0.009 | 0.028 | | 0.019 | | 0.212 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 2.36 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0.292 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | . | est<0.50 | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | . | est<0.20 |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 2.46 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 0 | <0.20 |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 2.32 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 2.1 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 5.95 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 1.85 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0 | <0.20 |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 2.19 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0.368 | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 1.4 | | 0.211 | | 0.022 | | 0 | <.018 | 0 | <0.20 |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 3.89 | | 0 | <0.009 | 0.027 | | 0 | <.018 | 0.333 | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 8.03 | | 0 | <0.009 | 0 | <0.011 | 0 | <0.018 | 1.77 | |
| bmpir | 1000021090 | 8/26/96 | 22:00 | 3.4 | | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| bmpir | 1000021091 | 8/27/96 | 2:00 | 0 | <1.25 | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| bmpir | 1000021092 | 8/27/96 | 6:00 | 2.51 | | 0 | <0.018 | 0 | <0.022 | 0 | <0.036 | . | est<.2 |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 1.92 | | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 1.77 | | 0 | <.0225 | . | est<.027 | 0 | <.045 | . | est<.50 |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 1.463 | | 0 | <.0225 | . | est<.027 | 0 | <.045 | . | est<.50 |

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0.954 | | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0.705 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0 | <1.00 | 0 | <.018 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0 | <.50 | 0.109 | | 0.033 | | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0 | <1.25 | 0.603 | | 0 | <.027 | 0 | <.045 | 0.665 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0.542 | | 0 | <.009 | 0.025 | | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 11.486 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 11.373 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.266 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0 | <1.00 | 0 | <.018 | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0 | ND <.50 | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 1.7 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0.22 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 2.88 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 3.4 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 1.06 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 1.08 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 1.75 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 1.12 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0.87 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0.81 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND <.018 | 0.24 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0.82 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0.89 | | . | EST<.011 | 0 | ND <.022 | 0 | ND <.036 | 0.22 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 1.07 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.26 | |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 1.06 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.3 | |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 1.12 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.23 | |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 1.14 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.28 | |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 1.28 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 1.09 | | 0 | ND <.011 | . | EST<.022 | 0 | ND <.018 | 0.28 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 2.14 | | 0 | ND <.009 | 0 | ND <.011 | 0 | ND<.018 | 0 | ND <.20 |
| bmpir | 1000026469 | 2/4/97 | 0:00 | 2.16 | | . | EST<.009 | . | EST<.011 | . | EST<.018 | 0 | ND <.20 |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 1.85 | | 0 | ND <.009 | . | EST<.011 | 0 | ND <.018 | 0.24 | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 1.97 | | 0 | ND <.009 | . | EST<.011 | 0 | ND <.018 | 0.22 | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0 | <3.28 | . | C97-228 | 0 | <.022 | . | EST1.48 | 0 | <.40 |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.724 | 0 | <.20 |

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.733 | 0 | <.20 |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.684 | 0 | <.20 |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.396 | 0 | <.20 |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.583 | 0 | <.20 |
| bmpir | 1000032693 | 6/14/97 | 22:00 | 0 | <3.45 | . | C97-228 | . | EST<.022 | . | EST<.036 | 0 | <.40 |
| bmpir | 1000032694 | 6/15/97 | 2:00 | 0 | <1.65 | . | C97-228 | . | EST<.011 | . | EST.36 | 0 | <.20 |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 8.45 | | . | C97-228 | 0 | <.011 | 0.265 | | 0 | <.20 |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 12.6 | | . | C97-228 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 5.78 | | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| condr | 1000021630 | 8/31/96 | 16:00 | . | est <.5 | 0 | <.009 | 0.027 | | 0 | <.018 | . | est<.20 |
| condr | 1000023112 | 9/27/96 | 23:00 | 1.005 | | 0.051 | | 0 | <.022 | 0 | <.036 | 0 | <.4 |
| condr | 1000023113 | 9/28/96 | 1:00 | 2.853 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.318 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 1.968 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| condr | 1000023175 | 10/5/96 | 2:00 | 1.274 | | 0.014 | | 0.018 | | 0.02 | | 0 | <.2 |
| condr | 1000023176 | 10/5/96 | 4:00 | 0.855 | | 0 | <.009 | 0.014 | | 0.018 | | 0 | <.2 |
| condr | 1000023177 | 10/5/96 | 6:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| condr | 1000023178 | 10/5/96 | 8:00 | 0 | <.5 | 0 | <.009 | 0.014 | | 0 | <.018 | 0 | <.2 |
| condr | 1000023179 | 10/5/96 | 10:00 | 0 | <.5 | . | EST<.009 | . | EST.016 | . | EST<.018 | 0 | <.2 |
| condr | 1000023189 | 10/5/96 | 20:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.698 | |
| condr | 1000023190 | 10/6/96 | 0:00 | 2.089 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.649 | |
| condr | 1000023191 | 10/6/96 | 4:00 | 2.427 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0.257 | |
| condr | 1000029148 | 3/11/97 | 8:00 | 1.15 | | 0 | <.011 | 0 | <.022 | 0 | <.036 | 0 | <.40 |
| conir | 1000018214 | 4/16/96 | 4:00 | 2.29 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018213 | 4/16/96 | 16:00 | 4.54 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018215 | 4/17/96 | 4:00 | 10.9 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000018455 | 5/16/96 | 0:00 | 7.27 | | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| conir | 1000018456 | 5/16/96 | 3:00 | 1.76 | | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| conir | 1000018457 | 5/16/96 | 6:00 | 1.33 | | 0 | <.009 | 0 | <.011 | . | IM | 1.01 | |
| conir | 1000018458 | 5/16/96 | 12:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0.95 | |
| conir | 1000018469 | 5/16/96 | 18:00 | 1.3 | | 0 | <.009 | 0 | <.011 | . | IM | 1.23 | |
| conir | 1000018470 | 5/17/96 | 0:00 | 1.15 | | 0 | <.009 | 0 | <.011 | . | IM | 0.85 | |
| conir | 1000018471 | 5/17/96 | 6:00 | 0.93 | | 0 | <.009 | 0 | <.011 | . | IM | 0.86 | |
| conir | 1000018472 | 5/17/96 | 12:00 | 1.06 | | 0 | <.009 | 0 | <.011 | . | IM | 0.85 | |
| conir | 1000018462 | 5/17/96 | 18:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | . | IM | 0 | <.2 |
| conir | 1000018463 | 5/18/96 | 0:00 | 2.36 | | 0 | <.009 | 0 | <.011 | . | IM | 1.99 | |
| conir | 1000018464 | 5/18/96 | 12:00 | 1.28 | | 0 | <.009 | 0 | <.011 | . | IM | 1.33 | |
| conir | 1000018473 | 5/18/96 | 18:00 | 0.92 | | 0 | <.009 | 0 | <.011 | . | IM | 1.98 | |

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 1.83 | | 0.217 | | 0.024 | | 0 | <0.018 | 0.212 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 1.25 | | 0 | <0.009 | 0 | <0.011 | 0 | <.018 | 0 | <0.20 |
| conir | 1000020859 | 8/18/96 | 23:00 | 0 | <1.00 | 0.185 | | 0 | <0.022 | 0 | <.036 | 0 | <0.40 |
| conir | 1000020860 | 8/19/96 | 2:00 | 0 | <0.50 | 0.428 | | 0.025 | | . | est<.018 | . | est0.739 |
| conir | 1000020861 | 8/19/96 | 8:00 | 0.551 | | 0 | <0.009 | 0.025 | | . | est<.018 | . | est0.202 |
| conir | 1000020862 | 8/19/96 | 14:00 | 2.109 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| conir | 1000020947 | 8/19/96 | 20:00 | 1.9 | | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est0.369 |
| conir | 1000020948 | 8/20/96 | 2:00 | 0 | <0.50 | 0 | <0.009 | 0 | <0.011 | . | est<.018 | . | est<0.20 |
| conir | 1000020949 | 8/20/96 | 8:00 | 4.74 | | 0 | <0.009 | 0.023 | | . | est<.018 | . | est0.434 |
| conir | 1000020950 | 8/20/96 | 14:00 | 5.9 | | 0 | <0.018 | 0 | <0.022 | . | est<.036 | . | est<0.40 |
| conir | 1000020966 | 8/20/96 | 20:00 | 0 | <0.50 | 0 | <0.009 | 0.032 | | 0 | <0.018 | 0.281 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0 | <0.50 | 0 | <0.009 | 0.025 | | 0 | <0.018 | 0 | <0.20 |
| conir | 1000020968 | 8/21/96 | 8:00 | 0.722 | | 0 | <0.009 | 0.03 | | 0 | <0.018 | 0.212 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0.924 | | 0 | <0.009 | 0.025 | | 0 | <0.018 | 0 | <0.20 |
| conir | 1000021095 | 8/26/96 | 18:00 | 0.531 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021096 | 8/26/96 | 22:00 | 3.06 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021097 | 8/27/96 | 2:00 | 1.299 | | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021098 | 8/27/96 | 6:00 | 0 | <.5 | 0 | <0.009 | . | est<.011 | 0 | <0.018 | . | est<.2 |
| conir | 1000021099 | 8/27/96 | 10:00 | 0 | <1.25 | 0 | <0.0225 | . | est<.027 | 0 | <0.045 | . | est<.5 |
| conir | 1000021100 | 8/27/96 | 14:00 | 0 | <1.00 | 0 | <0.018 | . | est<.022 | 0 | <0.036 | . | est<.4 |
| conir | 1000021141 | 8/27/96 | 18:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021142 | 8/27/96 | 22:00 | 0 | <.50 | 0 | <.009 | . | est<.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021143 | 8/28/96 | 2:00 | 0 | <1.00 | 0 | <.009 | . | est<.022 | 0 | <.036 | . | est<.40 |
| conir | 1000021144 | 8/28/96 | 6:00 | 0 | <1.25 | 0 | <.009 | . | est<.027 | 0 | <.045 | . | est<.50 |
| conir | 1000021145 | 8/28/96 | 10:00 | 1.51 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | . | est<.20 |
| conir | 1000021146 | 8/28/96 | 14:00 | 1.194 | | 0 | <.009 | 0 | <.027 | 0 | <.045 | . | est<.50 |
| conir | 1000021306 | 8/28/96 | 18:00 | 1.163 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021307 | 8/28/96 | 22:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021308 | 8/29/96 | 2:00 | 0 | <.50 | 0.079 | | 0.065 | | 0 | <.018 | 0 | <.20 |
| conir | 1000021309 | 8/29/96 | 6:00 | 0 | <.50 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000021310 | 8/29/96 | 10:00 | 0 | <.50 | 0 | <.009 | 0.127 | | 0 | <.018 | 0 | <.20 |
| conir | 1000021311 | 8/29/96 | 14:00 | 0 | <.50 | 0 | <.009 | 0.036 | | 0.019 | | 0 | <.20 |
| conir | 1000021637 | 8/29/96 | 20:00 | 0 | <.5 | . | est<.009 | . | est<.011 | . | est<.018 | 0 | <.2 |
| conir | 1000021638 | 8/30/96 | 2:00 | 1.904 | | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| conir | 1000021639 | 8/30/96 | 8:00 | 0 | <.5 | 0 | <.009 | 0 | <.011 | 0 | <.018 | 0 | <.2 |
| conir | 1000021640 | 8/30/96 | 14:00 | 0 | <.5 | 0.882 | | 0.085 | | 0 | <.018 | 0 | <.2 |
| conir | 1000026427 | 1/29/97 | 18:00 | 2.29 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Atrazine value | Atrazine remark | Azinphos (methyl) value | Azinphos (methyl) remark | Malathion value | Malathion remark | Parathion (methyl) value | Parathion (methyl) remark | Permethrin (cis/trans) value | Permethrin (cis/trans) remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0 | ND <.50 | 0 | ND <.02 | 0 | ND <.025 | 0 | ND <.040 | 0 | ND <.44 |
| conir | 1000026429 | 1/30/97 | 2:00 | 2.69 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026430 | 1/30/97 | 6:00 | 2.77 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026431 | 1/30/97 | 10:00 | 1.63 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026432 | 1/30/97 | 14:00 | 1.31 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026434 | 1/30/97 | 18:00 | 2.22 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026435 | 1/30/97 | 22:00 | 1.21 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026436 | 1/31/97 | 2:00 | 0.99 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026437 | 1/31/97 | 6:00 | 0 | ND <.50 | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026438 | 1/31/97 | 10:00 | 2.02 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026439 | 1/31/97 | 14:00 | 2.55 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026446 | 1/31/97 | 18:00 | 2.83 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026447 | 1/31/97 | 22:00 | 1.28 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026448 | 2/1/97 | 2:00 | 1.1 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026449 | 2/1/97 | 6:00 | 0.79 | | 0 | ND <.018 | 0 | ND <.022 | 0 | ND <.036 | 0 | ND <.40 |
| conir | 1000026450 | 2/1/97 | 10:00 | 1.85 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026451 | 2/1/97 | 14:00 | 0.73 | | 0 | ND <.011 | 0 | ND <.014 | 0 | ND <.022 | 0 | ND <.25 |
| conir | 1000026458 | 2/1/97 | 18:00 | 0.89 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.24 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 1.18 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0 | ND <.20 |
| conir | 1000026460 | 2/2/97 | 6:00 | 0.85 | | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.25 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0 | ND <.50 | . | EST<.009 | 0 | ND <.011 | 0 | ND <.018 | 0.25 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.099 | 0 | <.20 |
| conir | 1000032690 | 6/14/97 | 6:00 | 0 | <1.78 | . | C97-228 | 0 | <.011 | . | EST.306 | 0 | <.20 |
| conir | 1000032691 | 6/14/97 | 10:00 | 0 | <1.65 | . | C97-228 | 0 | <.011 | . | EST.151 | 0.646 | |
| conir | 1000032698 | 6/14/97 | 14:00 | 10.1 | | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000032699 | 6/14/97 | 18:00 | 8.49 | | . | C97-228 | 0 | <.011 | 0.071 | | 0.515 | |
| conir | 1000032700 | 6/14/97 | 22:00 | 0 | <1.64 | . | C97-228 | 0 | <.011 | 0 | <.018 | 0 | <.20 |
| conir | 1000032701 | 6/15/97 | 10:00 | 5.65 | | . | C97-228 | 0 | <.011 | 0.097 | | 0 | <.20 |

| Site | Sample # | Date | Time | Prometryn value µg/L | Prometryn remark | Trifluralin value µg/L | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpdr | 1000021631 | 8/31/96 | 16:00 | 0 | <.06 | 0.054 | | |
| bmpdr | 1000021727 | 8/31/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021728 | 8/31/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021729 | 9/1/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021730 | 9/1/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000021731 | 9/1/96 | 4:00 | 0 | <.12 | 0 | <.10 | |
| bmpdr | 1000023114 | 9/27/96 | 23:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023115 | 9/28/96 | 1:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023180 | 10/5/96 | 0:00 | . | EST<.06 | 0 | <.05 | |
| bmpdr | 1000023181 | 10/5/96 | 2:00 | . | EST<.12 | 0 | <.1 | |
| bmpdr | 1000023182 | 10/5/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023183 | 10/5/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023184 | 10/5/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023185 | 10/5/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000023192 | 10/5/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029149 | 3/11/97 | 9:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029150 | 3/11/97 | 11:00 | 0 | <.06 | 0 | <.05 | |
| bmpdr | 1000029151 | 3/11/97 | 13:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000018210 | 4/15/96 | 4:00 | 0 | <.103 | 0 | <.086 | |
| bmpir | 1000018211 | 4/15/96 | 16:00 | 0 | <.060 | 0 | <.05 | |
| bmpir | 1000018212 | 4/16/96 | 4:00 | 0 | <.060 | 0 | <.05 | |
| bmpir | 1000018439 | 5/14/96 | 6:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018440 | 5/14/96 | 9:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018441 | 5/14/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018442 | 5/14/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018443 | 5/15/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018444 | 5/15/96 | 6:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018445 | 5/15/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018451 | 5/15/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018452 | 5/16/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018453 | 5/16/96 | 6:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018454 | 5/16/96 | 12:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018465 | 5/16/96 | 18:00 | . | IM | 0 | <.10 | |
| bmpir | 1000018466 | 5/17/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018467 | 5/17/96 | 6:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018468 | 5/17/96 | 12:00 | . | IM | 0 | <.05 | |

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000018459 | 5/17/96 | 18:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018460 | 5/18/96 | 0:00 | . | IM | 0 | <.05 | |
| bmpir | 1000018461 | 5/18/96 | 12:00 | . | IM | 0 | <.05 | |
| bmpir | 1000019617 | 6/24/96 | 17:00 | . | est<.2qc | 0 | <0.1 | |
| bmpir | 1000020510 | 8/14/96 | 8:00 | 0 | <0.06 | 0.065 | | |
| bmpir | 1000020511 | 8/14/96 | 12:00 | 0 | <0.06 | 0.053 | | |
| bmpir | 1000020512 | 8/14/96 | 16:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020513 | 8/14/96 | 20:00 | 0 | <0.06 | 0.07 | | |
| bmpir | 1000020514 | 8/15/96 | 0:00 | 0 | <0.06 | 0.094 | | |
| bmpir | 1000020515 | 8/15/96 | 4:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020678 | 8/16/96 | 9:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020679 | 8/16/96 | 12:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020680 | 8/16/96 | 15:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020750 | 8/16/96 | 20:00 | 0 | <0.12 | 0 | <0.10 | |
| bmpir | 1000020751 | 8/17/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020752 | 8/17/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020753 | 8/17/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020804 | 8/17/96 | 20:00 | 0.09 | | 0 | <0.05 | |
| bmpir | 1000020805 | 8/18/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020806 | 8/18/96 | 8:00 | 0 | <0.06 | . | est<0.05 | |
| bmpir | 1000020807 | 8/18/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020863 | 8/18/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020864 | 8/19/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020865 | 8/19/96 | 14:00 | 0 | <0.06 | 0.066 | | |
| bmpir | 1000020951 | 8/19/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| bmpir | 1000020952 | 8/20/96 | 2:00 | 0 | <0.06 | 0.066 | | |
| bmpir | 1000020953 | 8/20/96 | 8:00 | 0 | <0.06 | 0.052 | | |
| bmpir | 1000020954 | 8/20/96 | 14:00 | 0 | <0.06 | 0.058 | | |
| bmpir | 1000021089 | 8/26/96 | 18:00 | 0 | <.06 | 0.062 | | Broken |
| bmpir | 1000021090 | 8/26/96 | 22:00 | 0 | <.15 | 0 | <.125 | Broken |
| bmpir | 1000021091 | 8/27/96 | 2:00 | 0 | <.15 | 0 | <.125 | Broken |
| bmpir | 1000021092 | 8/27/96 | 6:00 | 0 | <.12 | 0.058 | | |
| bmpir | 1000021093 | 8/27/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021094 | 8/27/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021135 | 8/27/96 | 18:00 | 0 | ND <.06 | 0 | <.05 | |
| bmpir | 1000021136 | 8/27/96 | 22:00 | 0 | ND <.15 | 0 | <.125 | Broken |
| bmpir | 1000021137 | 8/28/96 | 2:00 | 0 | ND <.15 | 0 | <.125 | Broken |

Results of Water Quality Monito. - Arroyo Colorado Project

Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000021138 | 8/28/96 | 6:00 | 0 | ND <.06 | 0 | <.05 | |
| bmpir | 1000021139 | 8/28/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021140 | 8/28/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021312 | 8/28/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021313 | 8/28/96 | 22:00 | 0 | <.12 | 0 | <.10 | |
| bmpir | 1000021314 | 8/29/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021315 | 8/29/96 | 6:00 | 0 | <.15 | 0 | <.125 | |
| bmpir | 1000021316 | 8/29/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021317 | 8/29/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021632 | 8/29/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021633 | 8/30/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021634 | 8/30/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| bmpir | 1000021635 | 8/30/96 | 14:00 | 0 | <.12 | 0 | <.10 | |
| bmpir | 1000026440 | 1/31/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026441 | 1/31/97 | 22:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026442 | 2/1/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026443 | 2/1/97 | 6:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026444 | 2/1/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026445 | 2/1/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| bmpir | 1000026452 | 2/1/97 | 16:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026453 | 2/1/97 | 20:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026454 | 2/2/97 | 0:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026455 | 2/2/97 | 4:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026456 | 2/2/97 | 8:00 | 0 | ND <.06 | 0 | ND <.05 | |
| bmpir | 1000026457 | 2/2/97 | 12:00 | 0 | ND <.12 | 0 | ND <.10 | |
| bmpir | 1000026462 | 2/2/97 | 18:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026463 | 2/2/97 | 20:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026464 | 2/3/97 | 2:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026465 | 2/3/97 | 6:00 | 0 | ND <.06 | 0 | ND <.05 | RECIEVED PAST HOLDING TIME |
| bmpir | 1000026466 | 2/3/97 | 10:00 | 0 | ND <.06 | 0 | ND <.05 | RECEIVED PAST HOLDING TIME |
| bmpir | 1000026467 | 2/3/97 | 14:00 | 0 | ND <.12 | 0 | ND <.10 | |
| bmpir | 1000026468 | 2/3/97 | 18:00 | 0 | ND <.06 | 0.25 | | |
| bmpir | 1000026469 | 2/4/97 | 0:00 | . | EST<.06 | 0.25 | | |
| bmpir | 1000026470 | 2/4/97 | 6:00 | 0 | ND <.06 | 0.19 | | |
| bmpir | 1000026471 | 2/4/97 | 12:00 | 0 | ND <.06 | 0.16 | | |
| bmpir | 1000032683 | 6/13/97 | 18:00 | 0 | <.12 | 0.247 | | RECEIVED WARM |
| bmpir | 1000032684 | 6/13/97 | 22:00 | 0 | <.06 | 0.292 | | RECEIVED WARM |

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| bmpir | 1000032685 | 6/14/97 | 2:00 | 0 | <.06 | 0.15 | | RECEIVED WARM |
| bmpir | 1000032686 | 6/14/97 | 6:00 | 0 | <.06 | 0.182 | | RECEIVED WARM |
| bmpir | 1000032687 | 6/14/97 | 10:00 | 0 | <.06 | 0.212 | | RECEIVED WARM |
| bmpir | 1000032688 | 6/14/97 | 14:00 | 0 | <.06 | 0.154 | | RECEIVED WARM |
| bmpir | 1000032693 | 6/14/97 | 22:00 | . | EST<.12 | 0.352 | | |
| bmpir | 1000032694 | 6/15/97 | 2:00 | . | EST<.06 | 0.149 | | |
| bmpir | 1000032695 | 6/15/97 | 6:00 | 0 | <.06 | 0.083 | | |
| bmpir | 1000032696 | 6/15/97 | 10:00 | 0 | <.12 | 0.162 | | |
| bmpir | 1000032697 | 6/15/97 | 14:00 | 0 | <.06 | 0.081 | | |
| condr | 1000021630 | 8/31/96 | 16:00 | 0 | <.06 | . | est<.05 | |
| condr | 1000023112 | 9/27/96 | 23:00 | 0 | <.12 | 0 | <.1 | |
| condr | 1000023113 | 9/28/96 | 1:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023174 | 10/5/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023175 | 10/5/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023176 | 10/5/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023177 | 10/5/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023178 | 10/5/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023179 | 10/5/96 | 10:00 | . | EST<.06 | 0 | <.05 | |
| condr | 1000023189 | 10/5/96 | 20:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023190 | 10/6/96 | 0:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000023191 | 10/6/96 | 4:00 | 0 | <.06 | 0 | <.05 | |
| condr | 1000029148 | 3/11/97 | 8:00 | 0 | <.12 | 0 | <.10 | |
| conir | 1000018214 | 4/16/96 | 4:00 | 0 | <.060 | 0 | <.05 | |
| conir | 1000018213 | 4/16/96 | 16:00 | 0 | <.060 | 0 | <.05 | |
| conir | 1000018215 | 4/17/96 | 4:00 | 0 | <.060 | 0.109 | | |
| conir | 1000018455 | 5/16/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018456 | 5/16/96 | 3:00 | . | IM | 0 | <.05 | |
| conir | 1000018457 | 5/16/96 | 6:00 | . | IM | 0 | <.05 | |
| conir | 1000018458 | 5/16/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018469 | 5/16/96 | 18:00 | . | IM | 0 | <.05 | |
| conir | 1000018470 | 5/17/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018471 | 5/17/96 | 6:00 | . | IM | 0 | <.05 | |
| conir | 1000018472 | 5/17/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018462 | 5/17/96 | 18:00 | . | IM | 0 | <.05 | |
| conir | 1000018463 | 5/18/96 | 0:00 | . | IM | 0 | <.05 | |
| conir | 1000018464 | 5/18/96 | 12:00 | . | IM | 0 | <.05 | |
| conir | 1000018473 | 5/18/96 | 18:00 | . | IM | 0 | <.05 | |

Results of Water Quality Monitor. ͜ - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| conir | 1000020803 | 8/18/96 | 16:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020858 | 8/18/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020859 | 8/18/96 | 23:00 | 0 | <0.12 | 0 | <0.10 | |
| conir | 1000020860 | 8/19/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020861 | 8/19/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020862 | 8/19/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020947 | 8/19/96 | 20:00 | 0 | <0.06 | 0.107 | | |
| conir | 1000020948 | 8/20/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020949 | 8/20/96 | 8:00 | 0 | <0.06 | 0.053 | | |
| conir | 1000020950 | 8/20/96 | 14:00 | 0 | <0.12 | 0 | <0.10 | |
| conir | 1000020966 | 8/20/96 | 20:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020967 | 8/21/96 | 2:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020968 | 8/21/96 | 8:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000020969 | 8/21/96 | 14:00 | 0 | <0.06 | 0 | <0.05 | |
| conir | 1000021095 | 8/26/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021096 | 8/26/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021097 | 8/27/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021098 | 8/27/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021099 | 8/27/96 | 10:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021100 | 8/27/96 | 14:00 | 0 | <.12 | 0 | <.10 | |
| conir | 1000021141 | 8/27/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021142 | 8/27/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021143 | 8/28/96 | 2:00 | 0 | <.12 | 0 | <.1 | |
| conir | 1000021144 | 8/28/96 | 6:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021145 | 8/28/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021146 | 8/28/96 | 14:00 | 0 | <.15 | 0 | <.125 | |
| conir | 1000021306 | 8/28/96 | 18:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021307 | 8/28/96 | 22:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021308 | 8/29/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021309 | 8/29/96 | 6:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021310 | 8/29/96 | 10:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021311 | 8/29/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021637 | 8/29/96 | 20:00 | . | est<.06 | 0 | <.05 | |
| conir | 1000021638 | 8/30/96 | 2:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021639 | 8/30/96 | 8:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000021640 | 8/30/96 | 14:00 | 0 | <.06 | 0 | <.05 | |
| conir | 1000026427 | 1/29/97 | 18:00 | 0 | ND <.12 | 0 | ND <.10 | ONE BOTTLE RECEIVED BROKEN CAR# 97-0024 |

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

| Site | Sample # | Date | Time | Prometryn value | Prometryn remark | Trifluralin value | Trifluralin remark | Comments |
|---|---|---|---|---|---|---|---|---|
| conir | 1000026428 | 1/29/97 | 22:00 | 0 | ND <.15 | 0 | ND <.11 | |
| conir | 1000026429 | 1/30/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026430 | 1/30/97 | 6:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026431 | 1/30/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026432 | 1/30/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026434 | 1/30/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026435 | 1/30/97 | 22:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026436 | 1/31/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026437 | 1/31/97 | 6:00 | 0 | ND <.12 | 0 | ND <.10 | |
| conir | 1000026438 | 1/31/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026439 | 1/31/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026446 | 1/31/97 | 18:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026447 | 1/31/97 | 22:00 | 0 | ND <.12 | 0 | ND <.10 | |
| conir | 1000026448 | 2/1/97 | 2:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026449 | 2/1/97 | 6:00 | 0 | ND <.12 | 0 | ND <.10 | ONE BOTTLE IN TRANSIT |
| conir | 1000026450 | 2/1/97 | 10:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026451 | 2/1/97 | 14:00 | 0 | ND <.075 | 0 | ND <.06 | |
| conir | 1000026458 | 2/1/97 | 18:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026459 | 2/2/97 | 0:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026460 | 2/2/97 | 6:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000026461 | 2/2/97 | 12:00 | 0 | ND <.06 | 0 | ND <.05 | |
| conir | 1000032689 | 6/14/97 | 2:00 | 0 | <.06 | 0.165 | | RECEIVED WARM |
| conir | 1000032690 | 6/14/97 | 6:00 | 0 | <.06 | 0.187 | | RECEIVED WARM |
| conir | 1000032691 | 6/14/97 | 10:00 | 0 | <.06 | 0.144 | | RECEIVED WARM |
| conir | 1000032698 | 6/14/97 | 14:00 | 0 | <.06 | 0.081 | | |
| conir | 1000032699 | 6/14/97 | 18:00 | 0 | <.06 | 0.103 | | |
| conir | 1000032700 | 6/14/97 | 22:00 | 0 | <.06 | 0.069 | | |
| conir | 1000032701 | 6/15/97 | 10:00 | 0 | <.06 | 0.115 | | |

# APPENDIX F

## TIAER Final Report:
## Prediction of Effects of Best Management Practices on Agricultural Nonpoint Source Pollution in the Arroyo Colorado Watershed

TIAER

# PREDICTION OF EFFECTS OF BEST MANAGEMENT PRACTICES ON AGRICULTURAL NONPOINT SOURCE POLLUTION IN THE ARROYO COLORADO WATERSHED

*Joan Flowers, Nancy Easterling and Larry Hauck*

**February 1998**

Final Report to the Texas State Soil and Water Conservation Board
on the FY92 319(h) Agricultural/Silvicultural Nonpoint Source Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 994-592-713-420000005 1

and

Final Report to the Texas Water Development Board
on the Fate and Transport Modeling for the Section 319 Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 92-483-339

Texas Institute for Applied Environmental Research
Tarleton State University • Box T0410, Tarleton Station • Stephenville, Texas
(254) 968-9567 • FAX (254) 968-9568

**TIAER**

# PREDICTION OF EFFECTS OF BEST MANAGEMENT PRACTICES ON AGRICULTURAL NONPOINT SOURCE POLLUTION IN THE ARROYO COLORADO WATERSHED

*Joan Flowers, Nancy Easterling and Larry Hauck*

**February 1998**

Final Report to the Texas State Soil and Water Conservation Board
on the FY92 319(h) Agricultural/Silvicultural Nonpoint Source Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 994-592-713-4200000051

and

Final Report to the Texas Water Development Board
on the Fate and Transport Modeling for the Section 319 Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 92-483-339

Texas Institute for Applied Environmental Research
Tarleton State University • Box T0410, Tarleton Station • Stephenville, Texas
(254) 968-9567 • FAX (254) 968-9568

# EXECUTIVE SUMMARY

This section 319(h) project was designed to promote the adoption of best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the Arroyo Colorado study area. The project was funded by the U.S. Environmental Protection Agency through Texas Natural Resource Conservation Commission (TNRCC) and Texas State Soil and Water Conservation Board (TSSWCB), with some matching funding for mathematical modeling efforts provided by Texas Water Development Board. Project participants included the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Southmost Soil and Water Conservation District (SWCD), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. Primary tasks of the project included the establishment of coordinating committees, the installation of BMPs and monitoring of demonstration sites, mathematical modeling of the study area, and education and technology transfer.

TIAER's involvement, in addition to performing laboratory analyses on water samples collected at the demonstration sites, dealt primarily with the fate and transport modeling component of the project and is the main focus of this report. The modeling analysis of best management practices within the Arroyo Colorado study area applied the Environmental Policy Integrated Climate (EPIC) model to estimate the effects of BMP implementation throughout the study area. The EPIC model was applied to the demonstration sites and to agricultural regions of the study area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application.

A multi-layer GIS database for the study area was assembled as part of the mathematical modeling efforts. Data layers included soil type, land use/vegetative cover, topographical information, monitoring wells, and geographic/cartographic features. The agricultural portion of the study area was separated into categories based on soil type, crop, and farming practices (dryland or irrigation). Individual simulations were performed for each grouping, which were then aggregated into a representative picture of the agricultural portion of the study area. Simulations were performed to estimate changes in edge-of-field loading for scenarios with and without BMPs. BMPs appropriate for crops grown in the study area were selected by the project's advisory committees. Average annual loads of nutrients, pesticides and sediment were estimated for the study area based on the modeling results for the six BMPs listed below:

1. improved nutrient management,
2. improved residue management,
3. improved irrigation water management,
4. improved irrigation technology,
5. irrigation land leveling/precision land forming, and
6. integrated pest management (IPM).

A seventh scenario represented the implementation of appropriate combinations of the six BMPs for each category.

Mathematical modeling results, presented in the following table, indicated that substantial reductions in nutrient and pesticide loadings would be achieved from BMP implementation within the study area. Percent reductions in total nitrogen loads exceeding 30 percent were estimated for improved nutrient management, improved irrigation water management and improved irrigation technology. Improved nutrient management also had the greatest impact on total phosphorus loads with an estimated 15 percent reduction attributed to this BMP. With respect to pesticide and sediment losses from cropland areas, the two BMPs dealing with irrigation practices (improved irrigation water management and improved irrigation technology) showed the greatest potential in reducing contributions from the study area. Percent reductions estimated for total nitrogen, pesticide and sediment losses exceeded 60 percent for all BMPs combined.

Although BMPs dealing with land leveling practices and integrated pest management (IPM) practices both displayed rather minor reductions in constituent loads, it should be kept in mind that these practices are largely implemented under the baseline condition, and this evaluation merely dealt with increasing the implementation in each case to 95 percent. It cannot and should not be concluded that these BMPs are not successful in reducing nonpoint pollution, but rather than much of the environmental benefits associated with these BMPs has already been realized. It would appear that educational and planning efforts by TAEX, NRCS, TSSWCB and other organizations in promoting integrated pest management and land leveling practices have been largely successful in effecting implementation among area producers.

**Percent Reduction in Losses[1] From BMP Implementation in the Arroyo Colorado Study Area**

| BMP | Nitrogen Loss | Phosphorus Loss | Pesticide Loss | Sediment Loss[2] |
|---|---|---|---|---|
| Improved Nutrient Management | 34 | 15 | 0 | 0 |
| Improved Residue Management | 0 | 2 | 8 | 18 |
| Improved Irrigation Water Management | 30 | 4 | 30 | 30 |
| Improved Irrigation Technology | 45 | 5 | 28 | 43 |
| Increase in Land Leveling to 95% | 0 | 5 | 5 | 21 |
| Increase in IPM Implementation to 95% | 0 | 0 | 1 | 0 |
| Implementation of all applicable BMPs | 64 | 27 | 62 | 62 |

[1]Represents total edge-of-field losses including surface and subsurface transport pathways
[2]Represents loss due to water erosion

# ACKNOWLEDGMENTS

EPIC (Environmental Policy Integrated Climate), formerly the Erosion Productivity Impact Calculator, was developed by United States Department of Agriculture Agricultural Research Service (USDA-ARS) scientists at the Grassland, Soil and Water Research Laboratory, collocated at Blackland Research Center (BRC). Modification and refinement of model processes in the development of the current version (version 5300) were performed by J.R. Williams at BRC.

TIAER also wishes to recognize the following Extension specialists at the Texas Agricultural Experiment Station, Research and Extension Center in Weslaco, who assisted in developing the crop management schedules used in the modeling analyses: John W. Norman, Jr., Extension Agent-IPM; Julian Sauls, Extension Horticulturist (Citrus); and Alton N. Sparks, Jr., Extension Entomologist.

Other specialists who provided assistance to TIAER in developing the crop management assumptions include John Bremer, Professor and Extension Weed Control Expert with the Texas A&M University System in Corpus Christi; Norman Rozeff, Agriculturist for the Rio Grande Valley Sugar Growers, Inc. in Santa Rosa; and Jack Garner, irrigation engineer of the Harlingen Irrigation District.

TIAER would also like to thank David Petit of the United States Army Corps of Engineers, Galveston District for providing land-use and soil GIS coverages for the area and Gerald Anderson with the Remote Sensing Research Unit of the USDA-ARS Subtropical Agricultural Research Laboratory (SARL) in Weslaco for providing the land-use data for citrus groves in Cameron County.

TIAER also wishes to recognize and thank the private landowners who participated in this project. These landowners permitted access to their property for monitoring and demonstration activities and tolerated the imposition of both the equipment and personnel required for this study. These landowners were also willing to manage portions of their fields differently for the sake of demonstration which no doubt required additional labor.

The authors would also like to recognize TIAER staff who contributed to this project including Teresa Salyer, who was responsible for assembling and maintaining TIAER's GIS database, Mark Murphy, who as manager of TIAER's chemical laboratory, was responsible for sample analysis and quality assurance, and Judy James who was responsible for graphics and report production. Also contributing were numerous technical support staff including chemists Tina Damron, Jason Owen, Jeri Howard, Gary Franklin and Jeff Howard and computer programmers Suresh Katuri and Jim Rogers.

# TABLE OF CONTENTS

# LIST OF TABLES



# LIST OF FIGURES

# LIST OF TABLES



# LIST OF FIGURES

# Evaluation of Best Management Practices for Reduction of Nonpoint Source Pollution in the Arroyo Colorado Watershed

## 1.0 INTRODUCTION

The Arroyo Colorado watershed, located in the coastal border region of southern Texas, has experienced numerous water quality problems in recent years. Evidence points to agriculture, one of the primary industries of the area, as one possible source of the pollution. This U.S. Environmental Protection Agency (USEPA) funded section 319(h) project serves to demonstrate best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the project area, to promote their adoption among area producers, and to estimate the effects of BMP implementation on local water quality.

The project was developed by the Texas Natural Resource Conservation Commission (TNRCC), Texas State Soil and Water Conservation Board (TSSWCB) and the Southmost Soil and Water Conservation District. Cooperating agencies include the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. The project was funded by the USEPA through TNRCC and TSSWCB, with some matching funding for modeling efforts provided by Texas Water Development Board (TWDB). This project addresses the impact of nonpoint source pollution resulting from agricultural sources, while the TNRCC has also developed a companion project addressing nonpoint source pollution resulting from urban runoff to the Arroyo Colorado. In addition to the cooperating agencies, local citizens and technical experts were involved with the project through coordinating committees established early in the project. Local and technical advisory committees were established to provide guidance for research and educational activities.

The overall objective of the project was to promote the adoption of BMPs to abate nonpoint source pollution from agricultural sources in the project area. Specific objectives of this project were to:

- demonstrate improved nutrient and pesticide management practices;
- evaluate the effectiveness of selected BMPs through monitoring of edge-of-field losses, both surface and subsurface, at the demonstration sites;
- estimate the environmental benefits of widespread BMP implementation through the use of mathematical models to predict pollutant load reductions for the study area; and
- promote increased cooperation and exchange of information between agricultural interest groups through the technical advisory committee and the local advisory committee.

Two fields were selected for implementation and demonstration of BMPs suitable to the project area. One demonstration field employed dryland cropping practices while the other was irrigated. To evaluate the effectiveness of selected BMPs in abating nonpoint source pollution associated with agricultural drainage, each field was divided into a control section which was managed according to conventional practices and a treatment section utilizing improved management practices. Samples of surface runoff and subsurface drainage were collected from the control and treatment sections of the fields for chemical analyses.

This report addresses TIAER's work elements which dealt specifically with the modeling analysis of best management practices within the Arroyo Colorado study area. The Environmental Policy Integrated Climate (EPIC) model, version 5300, formerly known as the Erosion Productivity Impact Calculator (Williams, 1995) was applied to estimate the effects of BMP implementation throughout the project area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application to the study area. Companion reports prepared by TAEX address the demonstration and educational activities associated with this project.

# 2.0 BACKGROUND

The Arroyo Colorado River (Figure 1) drains the flat coastal plain in southernmost Texas, as part of the Nueces-Rio Grande Coastal basin. Approximately 143 kilometers (89 miles long), the river stretches from its headwaters in Hidalgo County, across Cameron County, and empties into the Laguna Madre, just north of the Cameron-Willacy County line. The land in the Arroyo Colorado watershed was originally deposited by the ancient Rio Grande. Unlike other areas of the Texas coastal plain, the Arroyo Colorado watershed is not characterized by swamps and marshes (Brown *et al.*, 1980). Resacas, i.e., shallow abandoned meandering watercourses, are distinguishing features of the landscape.

Rainfall across the watershed averages 56 to 66 centimeters (22 to 26 inches) annually, categorizing it as a semi-arid region (TDWR, 1984). Municipal wastewater treatment plant effluent and irrigation return flows supersede rainfall runoff as the major contributors to the river's flow. Average annual lake evaporation in the Arroyo Colorado watershed is approximately 81 centimeters (32 inches) greater than average annual precipitation (USDA, 1977).

Much of the soil in the Arroyo Colorado watershed is fertile, easily cultivated, and suitable for irrigation if adequate drainage is available (USACE, 1990a). The alluvial soils of the watershed serve to make the area one of the most productive agricultural regions of Texas. According to the 1992 Census of Agriculture, one-third of Cameron County's 300,190 hectares (741,760 acres) are used as cropland. Cotton and grain sorghum are the most prominent crops in the county (Texas Agricultural Statistics, 1996). Corn, sugarcane, and citrus fruits represent other important crops in the area.

Although agriculture is the major economic activity, oil and gas production also support the area's economy. Harlingen, Mission, Donna, San Benito and other communities add urban influences within the watershed.

Surface water serves almost exclusively as the source of irrigation water for the vast agricultural enterprises of the area. The surface water derives primarily from streamflow diverted from the Rio Grande through leveed floodways and stored in constructed reservoirs in the Arroyo Colorado watershed. A limited amount of groundwater is used in the western part of the watershed, although it is typically of poorer quality than is the surface water (USACE, 1990a). In years of insufficient flow in the Rio Grande, however, up to 25 percent of the total water demand has been supplied by groundwater (USACE, 1990a). The western half of the Arroyo Colorado watershed is underlain by the shallow Gulf Coast aquifer. No major nor minor aquifers underlie the eastern half of the Arroyo Colorado watershed, although shallow, variably saline groundwater is found in the area. A review of the Texas Water Development Board's Ground Water Data System from 1990 - 1996 reveals that water table depths varied from 3.8 to 4.8 meters (12.5 to 15.6 feet) for area wells.

The Arroyo Colorado is one of the more complex watercourses in the state. From its headwaters to its mouth, it has been extensively modified by human activity, which affects both its hydrology and water quality. The low-relief, arid watershed is artificially plumbed by canals, aqueducts, siphons and pumping stations to provide irrigation water for the vast agricultural enterprises of the region. Similarly, the drainage of the basin's urban areas consists of rectified, leveed intersecting channels with gates for controlling and directing flow to alleviate chronic flooding problems common to the region. Numerous reservoirs have been constructed as catchment basins for irrigation water. Leveed floodways divert excess water caused by upland flooding from the Rio Grande to the Arroyo Colorado channel. The runoff response of the river is, therefore, quite different from what would be expected on the basis of natural runoff processes.

This system of floodways, in fact, complicates designation of the headwaters of the Arroyo Colorado. The floodway system begins in western Hidalgo County near Mission, Texas where water flows from the Rio Grande to the Main Floodway. The Main Floodway widens to become the Llano Grande Lake near Mercedes, Texas, in eastern Hidalgo County. A constructed channel sends flow from the lake to the Arroyo Colorado. In times of high water and flood conditions, a divisor dike also diverts flood water to the North Floodway, which traverses the northern part of Cameron County to Willacy County and empties into the Laguna Madre near the mouth of the Arroyo Colorado. The U.S. Army Corps of Engineers (USACE) and the USDA Natural Resources Conservation Service (NRCS) refer to the Arroyo Colorado as the waterway beginning east of the Llano Grande Lake. For regulatory purposes, the Texas Natural Resources Conservation Commission (TNRCC), however, considers the Arroyo Colorado to begin as the Main Floodway near Mission in western Hidalgo County.

The TNRCC recognizes three designated segments of the river: Segment 2200, the North Floodway, Segment 2201, Arroyo Colorado Tidal, and Segment 2202, Arroyo Colorado above Tidal. Segment 2201 extends approximately 42 kilometers (26 miles) from the Laguna Madre to roughly Port Harlingen, just east of the city of Harlingen. This segment, which is tidally influenced, has been dredged to accommodate barge traffic. Segment 2202 encompasses the remaining river from Port Harlingen to the headwaters. The North Floodway, designated at Segment 2200, is a distributary of the Arroyo Colorado river extending from the divisor dike near Llano Grande Lake to its terminus in the Laguna Madre.

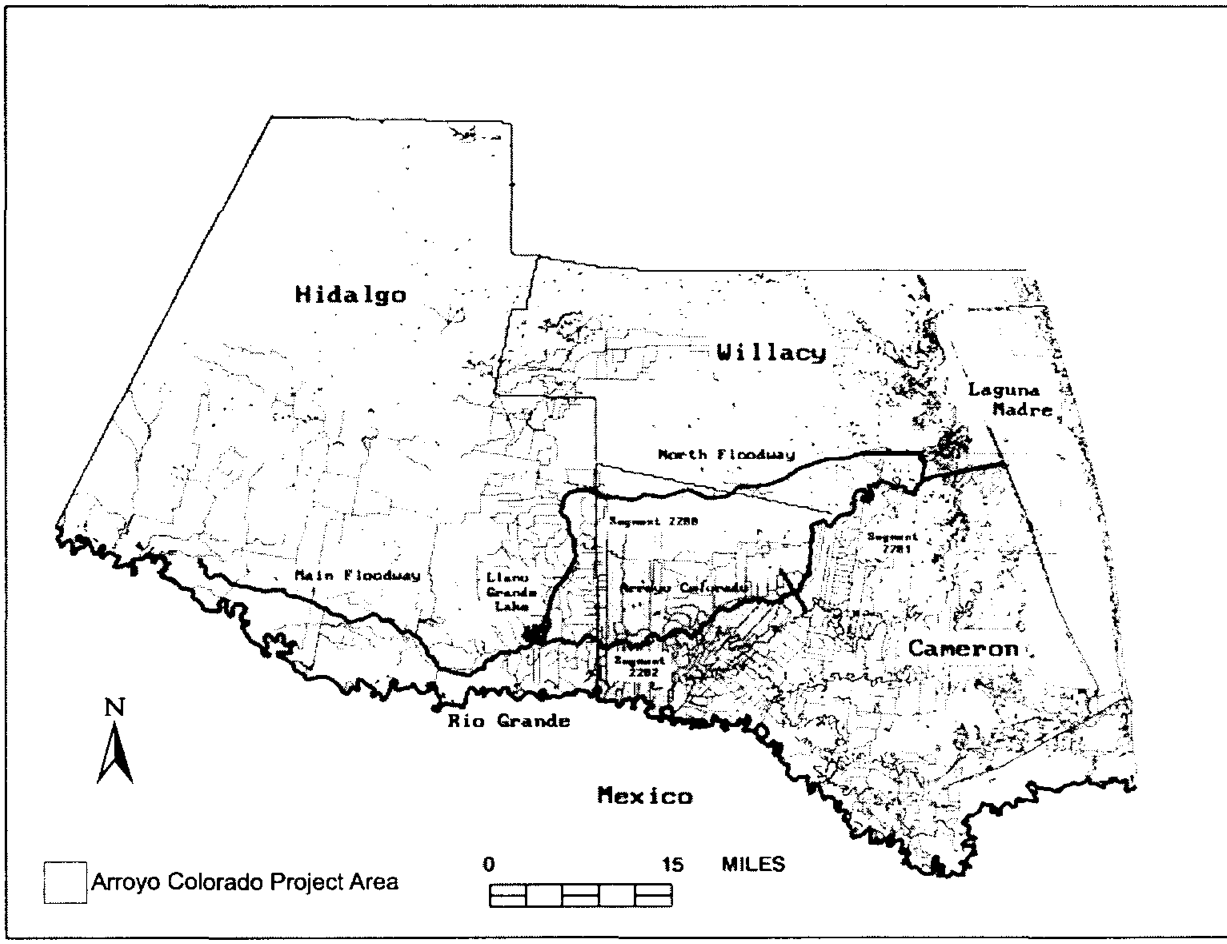



**Figure 1. The Arroyo Colorado River and its Tributaries**

## 2.1 Water Quality Issues in the Area

A review of the literature documents the numerous water quality problems plaguing the region. Over the years, various State agencies have investigated water quality-related issues in the Arroyo Colorado. Water quality problems in the Arroyo Colorado derive from various sources. The tidal segment experiences the expected saltwater intrusion and concomitant lower dissolved oxygen and higher salt content (Twidwell, 1978). Agricultural applications of pesticides and fertilizers, in conjunction with the irrigation and drainage systems of the area, have been implicated by various studies as contributing to water quality problems. Urban runoff and effluent from 26 wastewater treatment facilities in Segment 2202 and 6 facilities in Segment 2201 have also been cited as contributing to lower water quality in the Arroyo Colorado. It should be noted that some of these facilities receive wastewater that has been used to process agricultural products, further complicating the "source" issue. In fact, the *1990 Update to the Nonpoint Source Water Pollution Assessment Report for the State of Texas* (TWC & TSSWCB, 1991) listed the status of Segment 2202 as "Known Concern" due to elevated phosphorus, nitrogen, nutrients, fecal coliform, and chlordane in fish tissue. The potential sources identified for the segment were irrigated crop production, septic tanks, and urban sewers. A 1987 intensive priority monitoring of the Arroyo Colorado concluded that nonpoint sources, primarily agriculture, contribute the majority of the toxic pollutants to the Arroyo Colorado (TWC, 1989b).

Data collected from Segment 2201 by the Texas Department of Water Resources in 1976 indicated eutrophic conditions and the presence of pesticides in sediments (Twidwell, 1978). In 1980, the Texas Department of Health issued an advisory recommending restricted consumption of all fish from the Arroyo Colorado above Port Harlingen. Intensive surveys of Segment 2201, conducted by the Texas Department of Water Resources in the early to mid 1980s, consistently found evidence of eutrophication and pesticides. National Oceanic and Atmospheric Administration has reported that the Lower Laguna Madre watershed, which consists primarily of the Arroyo Colorado watershed, has the most intensively applied herbicides and insecticides of any watershed in Texas (TNRCC, 1994a). In addition, soil loss from cropland in the Lower Laguna Madre watershed exceeds that of the U.S. side of the Rio Grande Watershed, a decidedly larger area (TNRCC, 1994a).

The U.S. Army Corps of Engineers (USACE) performed a feasibility investigation during the late 1980s to determine the potential for reducing flood damage in the Cameron County, Texas (USACE, 1990a). Factors contributing to the area's frequent flooding include flat topography and poorly defined drainage courses. Human activities frequently increase the amount of accumulated rainfall remaining on the land for extended periods. Standing water can cause a subsequent rise in the water table which ultimately increases soil salinity, leading to non-productive soils. (USACE, 1990a). Corps engineers analyzed a full array of plans to provide flood damage reduction for the urban watersheds and agricultural watersheds, but determined that Federal participation would not be economically justified at that time (USACE, 1990a). The study found that

> [p]esticide contamination has been identified as a widespread problem of inland waters of the project area. The quality is also influenced by sewage effluent, cannery and food processing wastes, canal seepage and storm run-off. Increased runoff associated with any flood control or drainage project has the potential to increase these problems if proper planning efforts are not accomplished. Proper drainage design of agricultural land and implementation of various farming practices could significantly improve water quality of the area (USACE, 1990a).

The numerous above-ground irrigation canals in the watershed block natural drainage and increase flooding potential. The Corps recommends water conservation techniques and farming practices which could reduce the level of pesticides and improve water quality.

After a cluster of neural tube deficient babies were born in Cameron County in 1991, an evaluation by the Texas Department of Health (TDH) of data concerning air quality, soil constituents, drinking water quality, surface water quality and pesticide use revealed no clear causative agent (TNRCC, 1994a). A subsequent intensive small-scale pilot project conducted by the TDH in 1993 on nine families in the area found higher-than-average urinary arsenic levels yet relatively low levels of pesticides in participant blood and urine. Analysis of participants' food samples during this pilot project revealed that one fish caught in Donna Reservoir in the Arroyo Colorado watershed contained polychlorinated biphenyl (PCB) levels of 500 parts per million (ppm), well above the U.S. Food and Drug Administration action level of 2 ppm. Donna Reservoir receives water from the Rio Grande which is used for irrigation in the Arroyo Colorado watershed. Continuing investigations have consistently found PCBs in fish from the Arroyo Colorado but not from the Rio Grande (TNRCC, 1994a).

Water quality data have been collected by the TNRCC since 1982. Designated river segments were assigned to one of the following four categories with respect to each parameter: Concern, Possible Concern, No Concern and Insufficient Data. Table 1 presents all the parameters designated as a Concern or a Possible Concern for either of the two Arroyo Colorado segments for data collected from January 1983 through December 1992. Note: Insufficient data were collected from the Arroyo segments for all analyzed toxic substances, which accounts for their absence from this table.

**Table 1. TNRCC Water Quality Concerns for the Arroyo Colorado Segments**

| Parameter | Segment 2201 | Segment 2202 |
|---|---|---|
| Ammonia Nitrogen | Concern | Possible Concern |
| Nitrate Nitrogen | Concern | Concern |
| Total Kjeldahl Nitrogen | Not applicable to marine segments | Concern |
| Orthophosphate Phosphorus | Concern | Concern |
| Total Phosphorus | Possible Concern | Concern |
| Dissolved Phosphorus | Concern | Concern |
| Dissolved Oxygen | Concern | Possible Concern |
| Fecal Coliform | No Concern | Possible Concern |

From TNRCC, 1994a

A 1987 intensive monitoring study conducted by the Texas Water Commission (TWC, predecessor to the TNRCC) found relatively poor conditions for macrobenthic integrity in the above-tidal segment of the Arroyo Colorado, with pollution-tolerant species predominating and sensitive species absent (TWC, 1989b). Most sampling stations were rated as having "limited" aquatic life uses. The TWC researchers judged that the macrobenthic community was affected more by toxic chemicals found in the water and sediments in the upper portion of the watershed, rather than by the generally poor habitat conditions (TWC, 1989b). The tidal section of the river did not appear to have the toxic chemical effects of the upper portion. The 1987 study found that fish communities exhibited characteristics similar to those of macroinvertebrate communities, with physical habitat limitations and toxic conditions at sampling sites in the upper section of the river but more healthy fish communities in the lower section.

Fewer types of chemicals were detected in water, tissue, and sediment samples than were detected in a similar 1981 study. Concentrations of some of those chemicals decreased over time between the two studies, while concentrations of others increased. Toxicity tests were performed on water samples from various river sites and wastewater treatment plant effluent outfalls. Poor survival rates resulted from elevated chlorine and ammonia in effluent from Harlingen Wastewater Treatment Plant #2. The causative agent in the zero survival rate in a Ceriodaphnia dubia test from the Llano Grande Lake, however, could not be determined, although pesticides were suspected (TWC, 1989b). Concentrations of the following toxic chemicals found in tissue samples from the Arroyo Colorado fish present human health implications: methylene chloride, dieldrin, DDE, and chlordane. In addition, dacthal, a suspected human carcinogen, was found in very high levels in several tissue samples (TWC, 1989b).

In 1994, the Texas State Soil and Water Conservation Board named the Arroyo Colorado as one of only nine watersheds in the State identified with agricultural or silvicultural nonpoint source pollution concerns (TNRCC, 1994a). Segments 2201 and 2202 are both included on the State's 1996 303(d) list of priority watersheds (TNRCC, 1997). The 303(d) list notes that neither segment supports its designated aquatic life use and that Segment 2202 does not support its contact recreation use. In the 1994 *State of Texas Water Quality Inventory*, Segment 2202 was designated as number 7 out of 366 State watersheds with respect to priority action, while Segment 2201 was designated as number 20. The Inventory listed five fish kills from 1989 through 1992 in Segment 2202 and noted that fish contain elevated levels of chlordane, toxaphene and DDT. The summary for Segment 2202 in the 1994 *State Inventory* is as follows:

> This segment is not supporting its use for contact recreation due to the high fecal coliform levels. Phosphorus, nitrate and chlorophyll-α levels exceed the screening criteria in almost all of the samples collected in the segment. Elevated phosphorus and nitrogen levels promote excessive algal growth as indicated by elevated chlorophyll-α levels. Domestic effluents are the major contributor of nutrients to the segment during periods of normal flow. A wasteload evaluation has been completed and recommends advanced waste treatment to maintain stream standards. Concerns about toxic substances include manganese, selenium and DDE (a byproduct of DDT decomposition) in sediment and PCBs in fish tissue (TNRCC, 1994b).

The *1994 Regional Assessment of Water Quality in the Rio Grande Basin* (TNRCC, 1994a) noted that of all the segments of the Rio Grande basin and associated watersheds, only Segments 2202 and 2201 indicated dissolved oxygen problems. In a TNRCC ranking of the Rio Grande basin, including the Arroyo Colorado, the pollutants/stressors listed for both Arroyo segments were fish kills, relatively large number of permitted point source discharges, toxic conditions, depressed dissolved oxygen, and elevated levels of chlorophyll-α + pheophytin-α, nitrogen, and phosphorus (TNRCC, 1994a).

The summary for segment 2202 in the 1996 *State of Texas Water Quality Inventory* states:

> Nitrate plus nitrite nitrogen, orthophosphate, and total phosphorus concentrations exceed screening levels throughout the segment, promoting high primary productivity in the lower 35 miles, as indicated by elevated chlorophyll-α concentrations. In sediment,

angles. A 1990 feasibility report concerning flood damage prevention conducted by U.S. Army Corps (USACE, 1990a) contains detailed maps of the area's drainage channels and elevated irrigation canals. These maps were used to delineate the border of the project area.

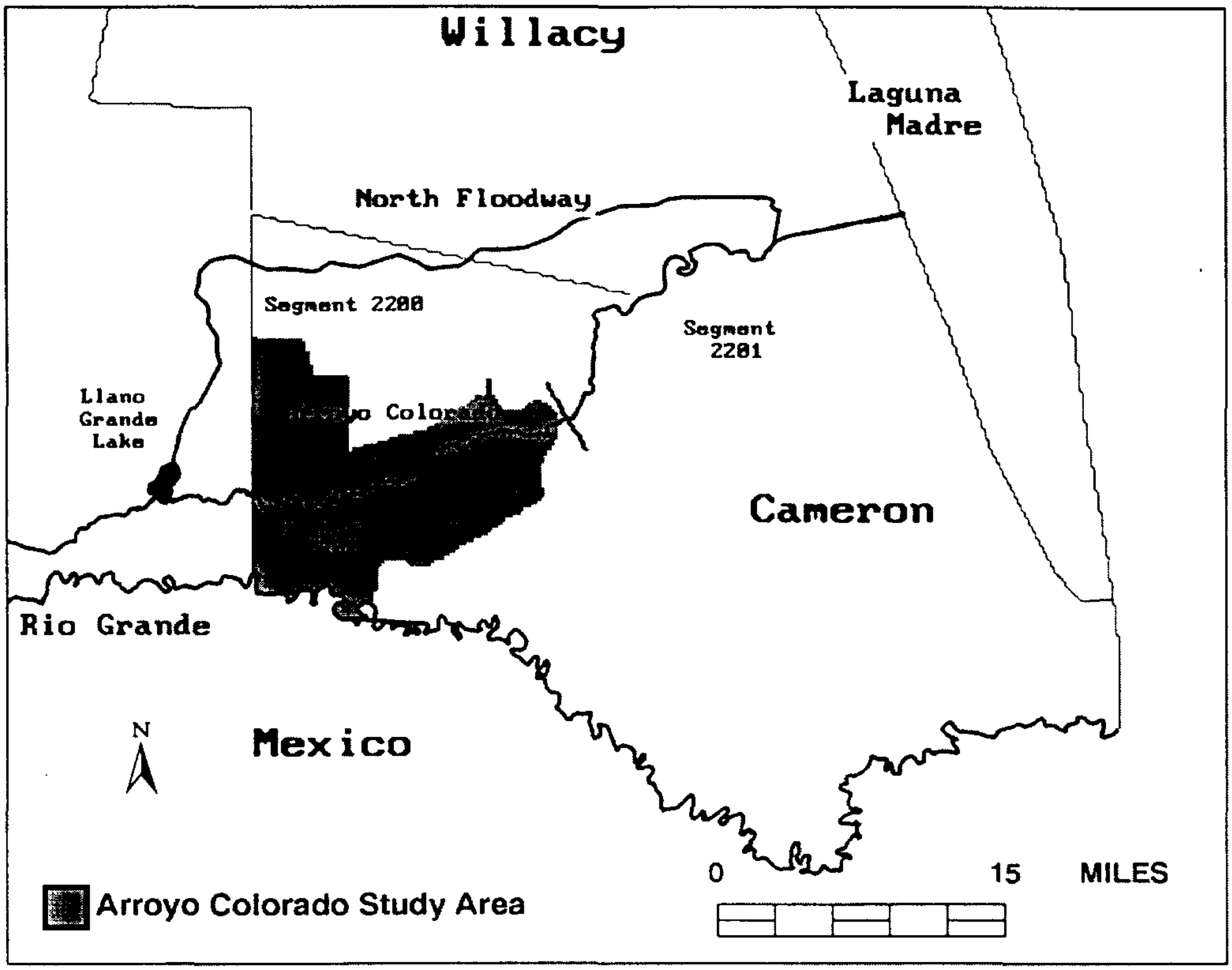



**Figure 2. Arroyo Colorado Project Study Area**

## 2.3 Demonstration Sites

In order to demonstrate best management practices that enable area farmers to reduce their contributions of pollutants to surface and ground water, project staff established two demonstration fields. Row crop operations in the project area include both irrigated and dryland farming, so one demonstration site of each type was implemented. On both sites, grain sorghum was grown for the first year and cotton was grown during the second year. Half of each site was set aside to serve as a control for comparisons of BMP effectiveness. The treatment and control fields were separated from surrounding fields and from each other by earthen berms. The location of the irrigated and dryland demonstration sites are denoted in Figure 3.

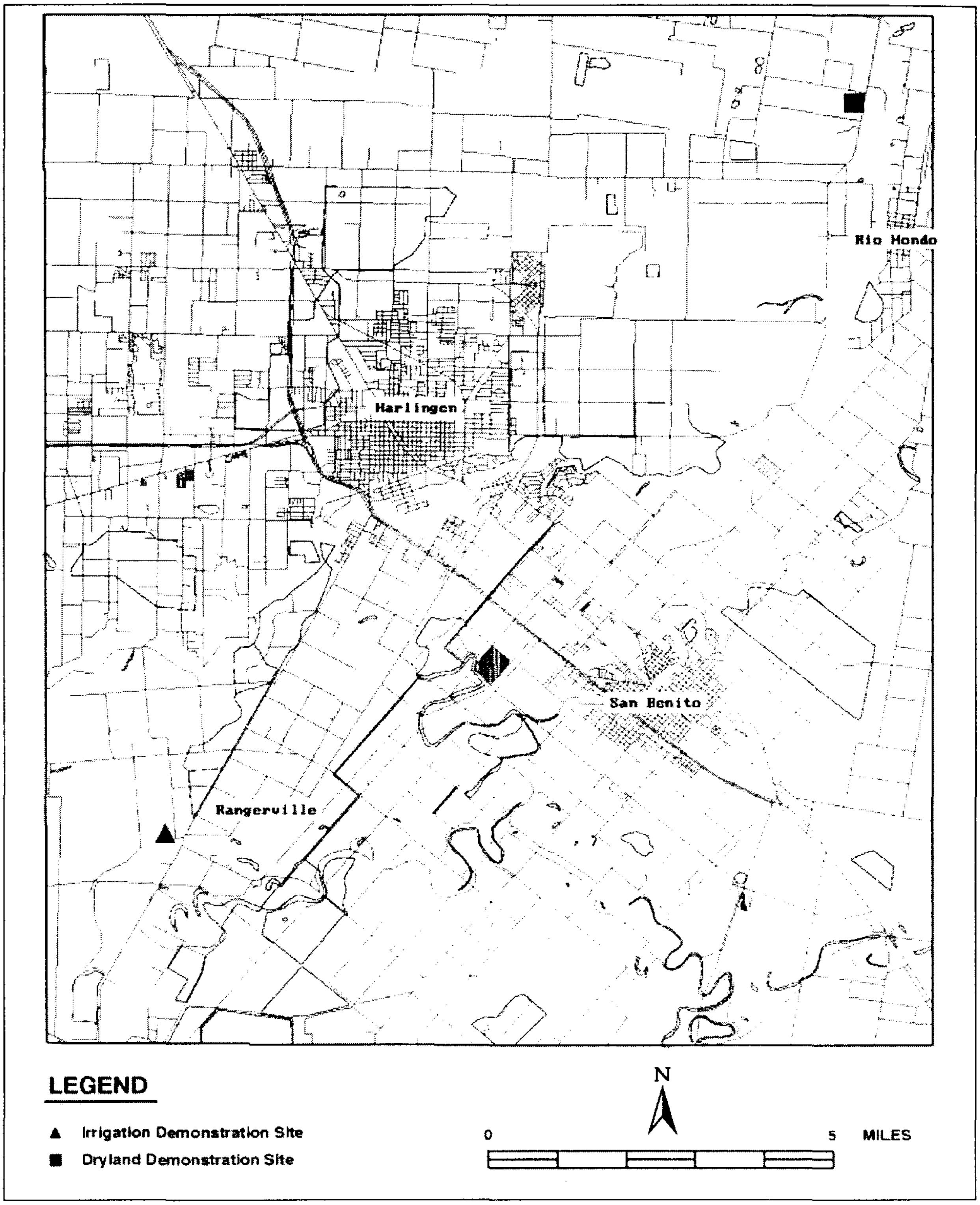



**Figure 3. Location of BMP Demonstration Sites**

### 2.3.1 Dryland Demonstration Site

The dryland site was located on 24 hectares (60 acres) north of Rio Hondo off FM1420, near Fort Perry in Segment 2202 (Figure 4). The site was divided into two fields of 12 hectares (30 acres) each, one field to demonstrate BMPs and the other to serve as a control. Both fields were underlain by Hidalgo silty clay loam and Raymondville clay loam. The Raymondville loam predominated in the control field, while the Hidalgo loam predominated in the BMP field. Atrazine was applied to the site for weed control during the spring of the first year. Roundup was applied to the grain sorghum in the fall to control post-harvest regrowth.

The BMPs employed on the dryland treatment site were the following:

- nutrient management utilizing split fertilizer applications, based on soil test results,
- crop residue management, and
- precision land forming.

Nutrient management includes soil tests to determine the correct amount of nutrients to use and splitting the applications of the nutrients. Two applications of nutrients (fertilizer) were applied during the plants' growing cycle on the treated field, one prior to planting and the other as a side dressing after crops had emerged. Split application of nutrients allows plants to use the nutrients more efficiently, resulting in optimum forage and crop yields, while minimizing the loss of nutrients to surface and groundwater. On the control field, all nutrients were applied prior to planting. Analyses of nutrients in surface runoff from this site were used to demonstrate the efficacy of this management practice.

The fertilizer applied to the field both years was a 32-0-0 commercial fertilizer, which was 32 percent nitrogen (½ urea and ½ ammonium-nitrate). Based on soil test analysis of the 0 to 30.5 centimeter (0-to-12 inch) layer for the first year's grain sorghum crop, 67 kilograms per hectare (60 pounds per acre) of nitrogen were recommended for the BMP area. For the control area, 90 kilograms per hectare (80 pounds per acre) of nitrogen were recommended as a typical rate used by producers without benefit of a soil test. For the second year's crop, with a projected cotton yield of 4.9 bales per hectare (two bales per acre), 101 kilograms per hectare (90 pounds per acre) of nitrogen, with no phosphorus nor potassium, were recommended for the dryland BMP field, with 56 kilograms per hectare (50 pounds per acre) applied at planting and 45 kilograms per hectare (40 pounds per acre) applied as the side dressing. The recommended rate of nitrogen for the dryland control area was 123 to 134 kilograms per hectare (110 to 120 pounds per acre) in a single application at planting, which was considered to be the normal application, without benefit of a soil sample.

Crop residue management was another BMP implemented on the dryland site to demonstrate the benefits of crop residues in reducing soil loss from both wind and water erosion. This practice involves the delaying of fall tillage operations to allow crop residues to remain on the field following harvest. By providing soil cover between growing seasons, crop residues serve to reduce both the runoff and sediment losses from cropland areas. Consequently a reduction in soluble and sediment-bound pollutants may be realized. To demonstrate this BMP, crop residues remaining after harvesting of the 1996 grain sorghum crop were allowed to remain on the treated field, while the residues were tilled into the soil of the control field.

Precision land forming refers to reshaping the surface of the field into planned, uniform grades. Land forming is designed to reduce the amount of excess surface water standing on the land, which can lead to elevated ground water and subsequent increased soil salinity. Reduction in surface ponding provides more uniform distribution of rainfall to subsurface soils. Precision land forming also helps to control erosion and reduce the amount of pesticides and nutrients leaving the site. The natural grade (slope) of the control side was 0.0013 (0.13 meters per 100 meters), while the slope on the BMP field was 0.00025 (0.025 meters per 100 meters).

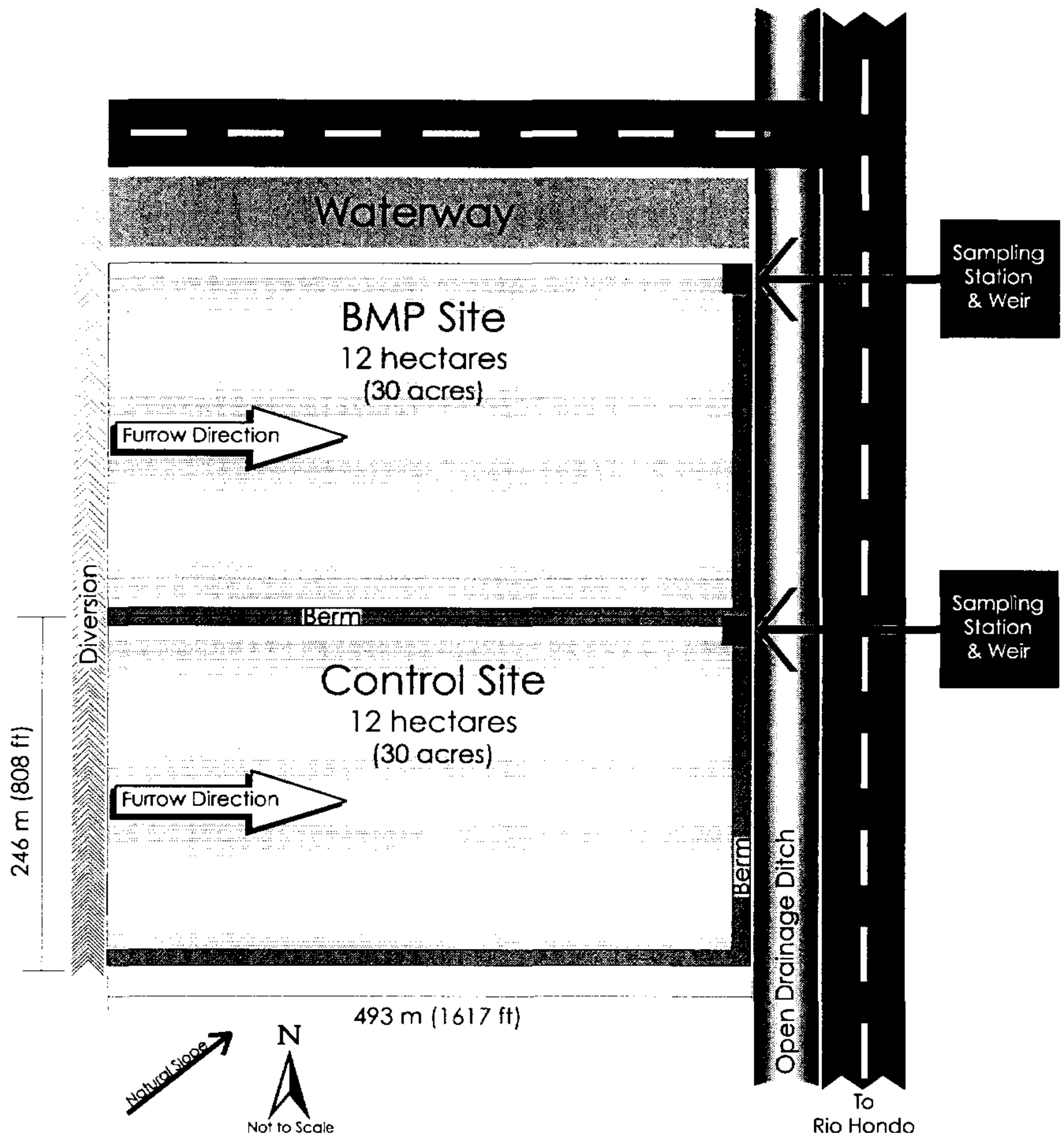



**Figure 4. Dryland Demonstration Site**

## 2.3.2 Irrigated Demonstration Site

The irrigated site was located on 16 hectares (40 acres) near Las Rusias off U.S. 281 and FM1479 in Segment 2202 (Figure 5). A subsurface drainage monitoring system was in place on this field prior to the project. Harlingen clay and Olmito silty clay are the dominant soils underlying the irrigated site, which was divided into two equal sections to serve as the BMP demonstration (treatment) and control sites.

The BMPs identified by project participants and recommended for irrigated cropland areas were the following:

- nutrient management by split fertilizer applications, based on soil test results,
- irrigation land leveling,
- proper irrigation water management, and
- improved irrigation technology.

Nutrient management was practiced on the irrigated site in the same manner as on the dryland site: split applications before and after plant emergence on the BMP plot and only prior to planting on the control plot. Residual amounts of nutrients in the soil were measured to determine fertilizer needs based on expected crop yields. For the first year's grain sorghum crop, based on the soil test, 56 kilograms per hectare (50 pounds per acre) of nitrogen were applied before planting the irrigated BMP area and 34 kilograms per hectare (30 pounds per acre) of nitrogen were applied as a side dress after the plants emerged. The irrigated control area was fertilized with 112 kilograms per hectare (100 pounds per acre) of nitrogen, considered as a typical rate, i.e., not based on a soil test, for grain sorghum. For an expected cotton yield of 4.9 bales per hectare (2 bales per acre) the second year, 67 kilograms per hectare (60 pounds per acre) of nitrogen were recommended for pre-planting and 45 kilograms per hectare (40 pounds per acre) of nitrogen as a side dressing on the irrigated BMP area. The recommended rate for the irrigated control area was 123 to 134 kilograms per hectare (110 to 120 pounds per acre) of nitrogen for the cotton crop.

Irrigation land leveling, is similar to the practice of precision land forming of dryland areas, which involves reshaping the land surface to planned, uniform grades. While the objective of precision land forming is to improve surface drainage of excess rainfall thereby reducing ponding of water in low lying areas, irrigation land leveling aids in the uniform distribution of irrigation water. Irrigation land leveling improves the efficiency of furrow irrigation systems which may reduce the amount of irrigation water required for crop production. Irrigation land leveling was implemented at this demonstration field prior to initiation of monitoring for this project and had been implemented for the entire field, both the treatment and control sections. Although this site demonstrates the practice of irrigation land leveling, monitoring activities could not be used to demonstrate the effectiveness of this practice in reducing pollutant losses since both the treatment and control sections were affected by this practice.

Two irrigation management practices which were evaluated for this project include improved irrigation water management and improved irrigation technology. Both practices influence the frequency, timing and volume of irrigation water applied to cropland areas. Improved irrigation water management typically involves a reduction in the irrigation volume applied during a single application. The timing of irrigation applications may also be adjusted based on crop water needs and soil moisture. Improved irrigation technology encompasses several newer irrigation methods which have been proven to increase system efficiency by reducing surface and subsurface losses including cut back irrigation, surge flow irrigation, and the use of gated pipe instead of siphon tubes for furrow irrigation systems. These irrigation BMPs are discussed in educational material developed by TAEX as part of this project (Stichler and Fipps, 1997).

Of the four practices recommended for irrigated cropland areas, only nutrient management and irrigation land leveling were implemented at this site. Although, the use of proper irrigation water management and improved irrigation technology were not demonstrated, these BMPs were evaluated through modeling analyses as part of this project.

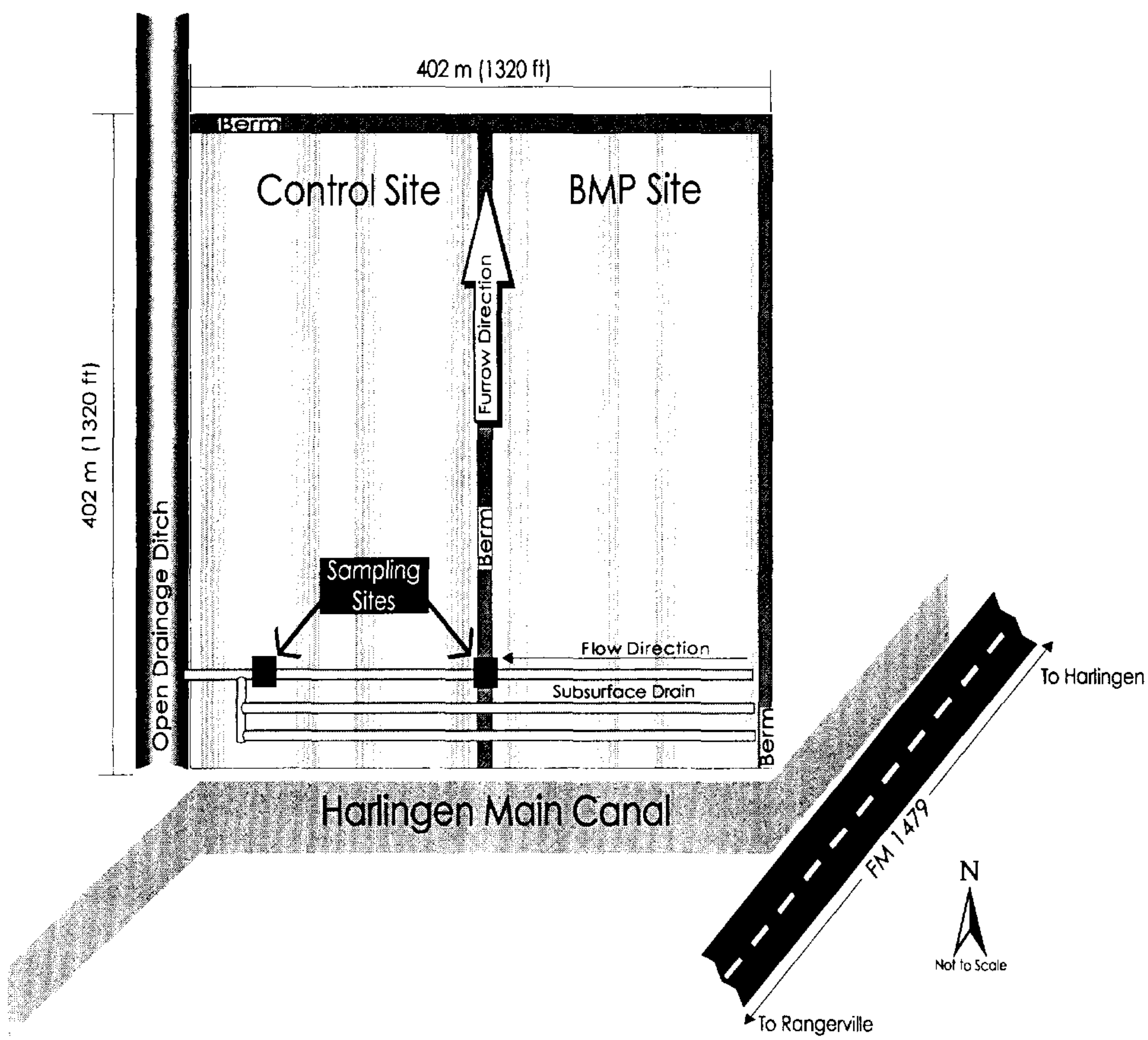



**Figure 5. Irrigated Demonstration Site**

# 3.0 INFORMATIONAL REQUIREMENTS FOR MODEL APPLICATION

Data assembled for the project model consisted of three types of data which were stored in digital format in TIAER databases. These data include geographically referenced data that were assembled to characterize the Arroyo Colorado study area, historical weather data for the area and water quality data collected during the course of this study. The methodology used to generate these data and the software and hardware configurations that were used to store and manipulate these data are discussed in the following sections.

## 3.1 Geographical Information System (GIS) Database

The geographic information system (GIS) employed by TIAER for the Arroyo Colorado project was the Geographical Resources Analysis Support System (GRASS), version 4.1.4 (U.S. Army, 1988). The GRASS system is a public domain GIS package developed by the Environmental Division of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). GIS data assembled for this project include vector and rastor map layers describing area soils, land use, vegetative cover, topography, topology, hydrography and the location of groundwater monitoring wells. The most current data available for the study area was obtained from appropriate sources, then each layer was converted into a consistent projection system. All project GIS data were converted to Albers Equals-Area Conic projection.

### 3.1.1 Soils

The soil data for the Arroyo Colorado study area were obtained from the U.S. Army Corps of Engineers (USACE, 1990b). The soil data, digitized from county soil maps at a 1:24,000 scale, is comparable to the Soil Survey Geographic (SSURGO) database maintained by the USDA-Natural Resources Conservation Service (NRCS). With the assistance of local NRCS personnel, the 21 soil series occurring in the study area were grouped according to their textural properties, intake curve and moisture holding capacity. The resulting GIS soil layer for the project contained seven general soil categories and is depicted in Figure 6 (see Appendix A for soils and characteristics included in each category).

Supplemental soil information characterizing the soil horizons, such as horizon thickness, depth, texture, and water holding capacity, are components used by the EPIC model in determining rainfall runoff, drain flow, and the movement of nutrients and pesticides. These data were obtained from the NRCS Soil Interpretations Record (SIR or SOIL-5) database and NRCS Map Unit Interpretive Database (MUIR). The soil extraction program, Map Unit Use File (MUUF, version 2.14, Baumer *et al.*, 1997), was used to extract and process soil information from the databases and to generate soil input required by the EPIC model. These data are also included in Appendix A.

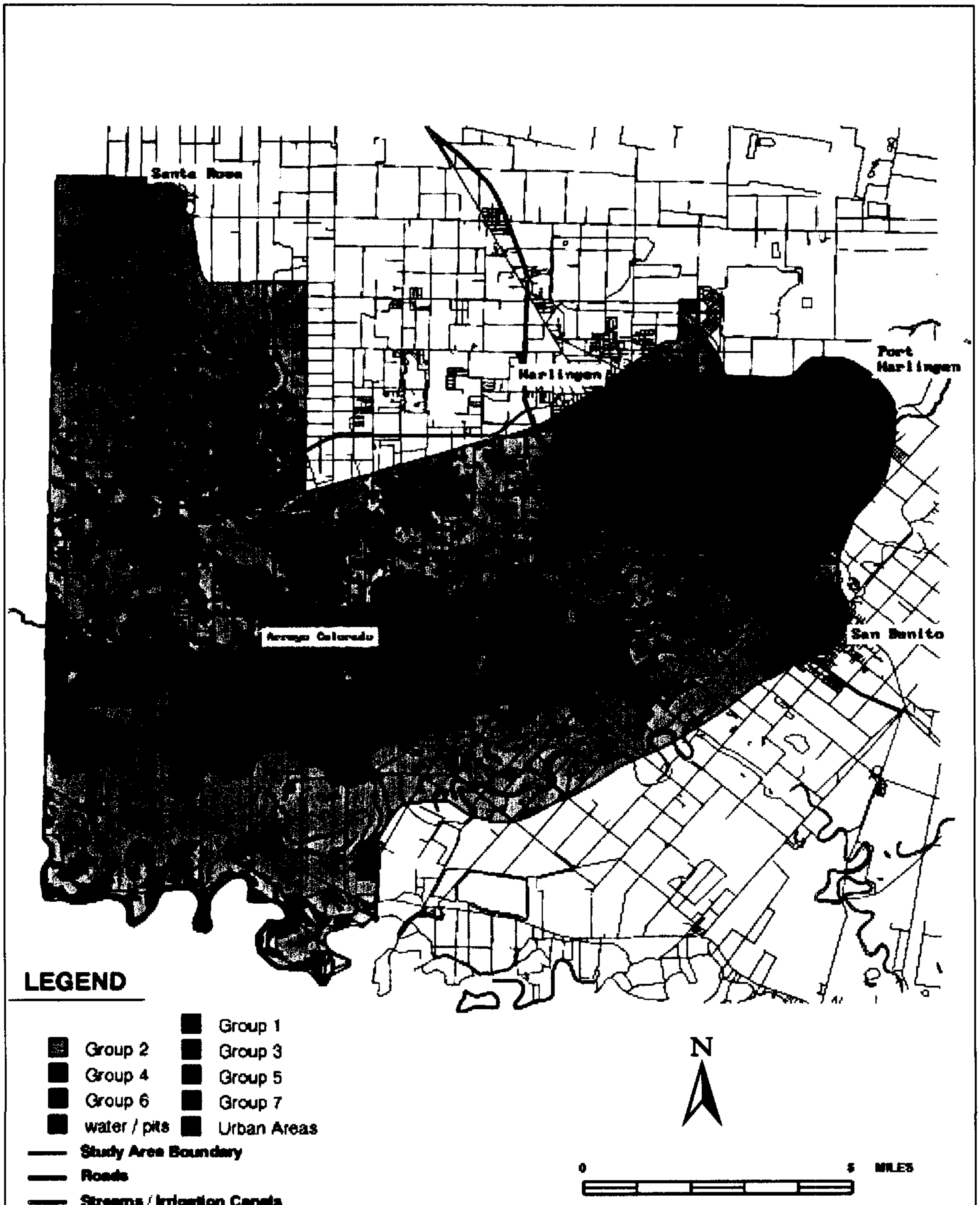



**Figure 6. Soil Classifications for the Arroyo Colorado Project Area**

### 3.1.2 Land-Use/Vegetative Cover Classification

Runoff from rainfall and irrigation are affected by land use and vegetative cover. Since land use is generally defined by broad categories such as urban, industrial, and agricultural, this information is often combined with vegetative cover information into a single GIS data layer. The most recently updated land-use data from the USACE, Galveston Office, at a 1:24,000 scale, provided the basis for the land-use/vegetative cover layer.

As the objective of the GIS data collection efforts was to characterize pertinent features of the study area for use in the modeling analysis, it was desirable to identify specific crop types and rotational patterns which could be used to generate EPIC datasets. Areas which were not targeted for modeling analysis of BMP implementation, including rangeland and pastureland, were lumped into a single category (non-row crop agriculture).

The original land-use coverage obtained from the USACE did not identify vegetable crops in any of their categories. Based on discussions with local project participants, it was determined that vegetables represent a very minor portion of the cropland in Cameron County. Acreage of all vegetables listed for Cameron County in the 1992 Agricultural Statistics database (Census of Agriculture, 1992), i.e., cantaloupes, watermelons, cabbages, onions, and bell peppers, represented less than one percent of the county's agricultural land in 1992. Furthermore, because soil types occurring in the study area are less suitable to cultivation of vegetables, it was assumed that most of the county's vegetable crops are grown outside of the project study area (Moore, 1997). For this reason, vegetable crops were not included in the modeling for the study area.

With the assistance of local NRCS personnel from the district office in San Benito, the land-use categories were modified to reflect current vegetative cover. The land-use/vegetative cover layer was also revised to reflect updated information on the location of citrus orchards in Cameron County using data obtained from the USDA-ARS Remote Sensing Lab in Weslaco. Five categories based on crop type, and one non-agricultural category comprise the land-use/vegetative cover GIS layer depicted in Figure 7. These categories include the following:

- irrigated cotton in rotation with either grain sorghum or corn,
- dryland cotton in rotation with either grain sorghum or corn,
- irrigated sugarcane,
- irrigated citrus,
- non-row crop agriculture/perennial vegetation (includes rangeland and pastureland), and
- non-agricultural areas (includes urban areas, surface water and excavated areas).

Although the amount of dryland farming in the region is very small in comparison to the amount of irrigated farmland, these areas were included in the modeling because of their potential to impact the results of Best Management Practice (BMP) analyses. The management practices characteristic of the two types of farming can result in large differences in response to runoff events. Furrows of irrigated farmland are bermed to block the ends and retain irrigation water, minimizing the required volume of irrigation water. The water percolates through the soil to the subsurface drainage system, then empties into drainage canals. The blocked ends also maximize soil moisture from rainfall, while the subsurface drainage system diminishes potential oversaturation.

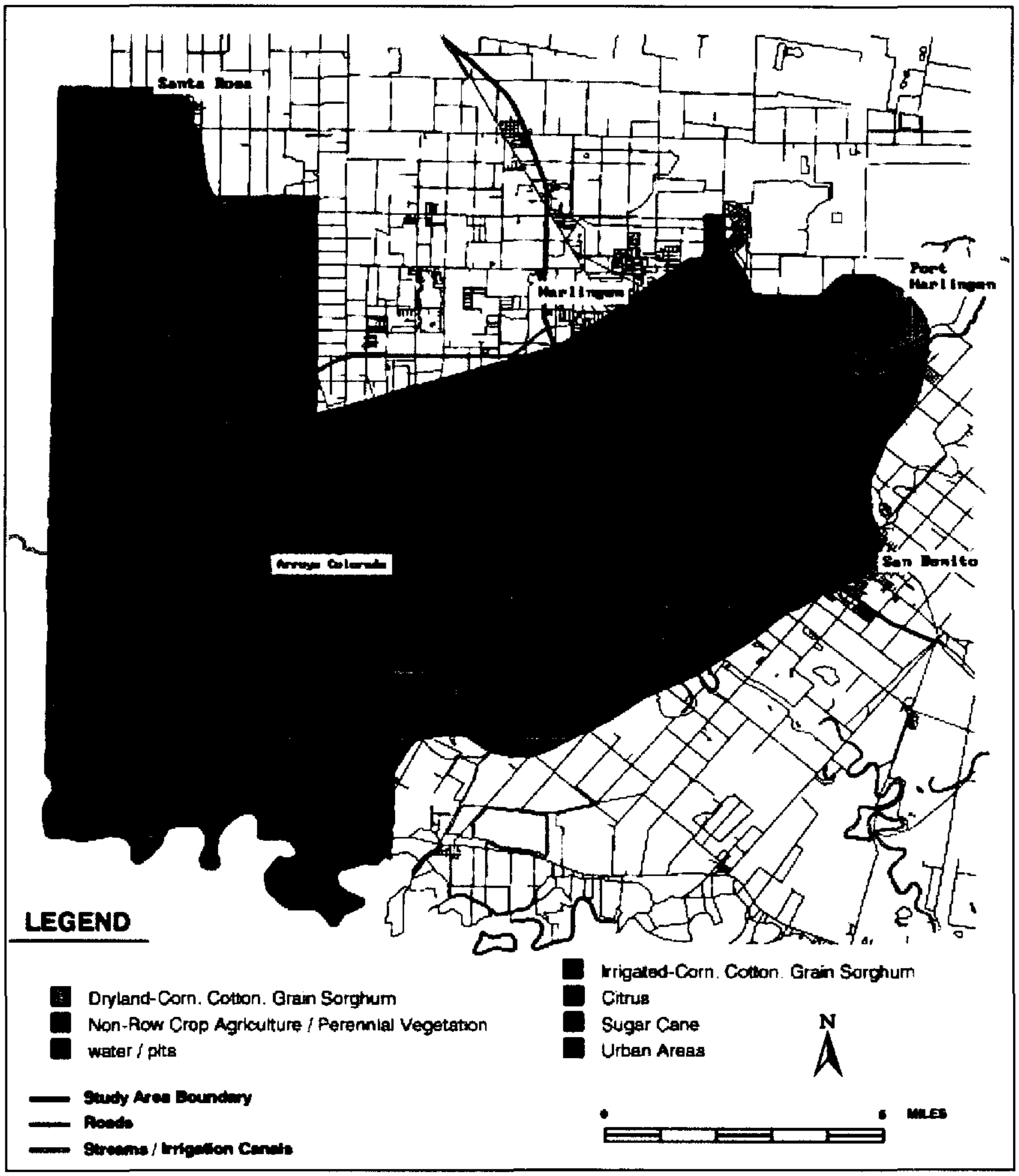



**Figure 7. Land Use/Vegetative Cover Classifications for the Arroyo Colorado Project Area**

The Non-Row Crop Agriculture/Perennial Vegetation category includes native and improved pastureland and rangeland maintaining a combination of perennial grasses, trees and shrubs. Vegetation in this category include forage sorghum, buffalograss, grama, blue grama, bluestem, guinea grass, bermuda grass, greasewood, big sage, acacia, granjeno, mesquite, saltbush, and willows.

GIS data relating to crop cover and soil type were used to identify selected crop production areas and the extent of their occurrence on various soil types within the study area. Based on crop cover and soil data, cropland acreages within the study area were calculated (see Appendix B). Non-cropland areas such as urban areas, rangeland and pastureland were excluded in the modeling of the effect of BMP implementation on nutrient and pesticide losses from intensively cultivated cropland areas (i.e., row crops) in the study area. Based on recommendations from the Project Technical Advisory Committee, a land-use assumption designated that 85 percent of area cotton crops were rotated with grain sorghum and the remaining 15 percent were rotated with corn (Moore, 1997).

Land uses in the Arroyo Colorado study area are summarized in Table 2. The vast majority of land (89 percent) in the Arroyo Colorado study area is used for crop production. Irrigated row crop production accounts for more than 68 percent of the study area land use, while dryland row crops occupy less than 1 percent. Cotton is the most widely grown crop, representing approximately 59 percent of the study area. Non-agricultural applications include urban areas, which occupy approximately 7 percent of the area, and water and excavation pits, which occupy almost 4 percent.

**Table 2. Land Uses in the Arroyo Colorado Study Area**

| | | | | |
|---|---|---|---|---|
| Agricultural Land Uses | | | | |
| Row crops | | | | |
| Irrigated | | | | |
| Cotton-Grain Sorghum | 49% | | | |
| Cotton-Corn | 9% | | | |
| Sugar Cane | 8% | | | |
| Citrus | 2% | | | |
| Total Irrigated | 68% | | | |
| Dryland | | | | |
| Cotton-Grain Sorghum | 0.7% | | | |
| Cotton-Corn | 0.1% | | | |
| Total Dryland | 0.8% | | | |
| Total Row Crops | | 69% | | |
| Non-row crops | | 20% | | |
| Total Agricultural Land Uses | | | 89% | |
| Non-agricultural Land Uses | | | 11% | |
| Total Land Uses | | | | 100% |

### 3.1.3 Topographical Data

Topographical data traditionally is one of the determining factors in predicting rainfall runoff. A topographical GIS layer comprised of USGS DEM (digital elevation model) in the form of elevation contour lines on a 1:250,000 scale was obtained for the project study area. The units of measure for DEM data are 3 arc-seconds (300 meter grid cells). These data are commonly used to define drainage basins and determine land slopes. However, the artificial plumbing of the watershed renders topographical data ineffective in predicting runoff direction. The topographical GIS layer was therefore not used in the modeling efforts.

### 3.1.4 Monitoring Wells

Monitoring well data were used to estimate depth to groundwater. Location (latitude and longitude) of groundwater monitoring wells in the study area were obtained from Texas Water Development Board UM-50 Ground-Water Data System (Nordstrom and Quincy, 1993). Nineteen wells for which groundwater level data are available for 1990 through 1996 were identified and plotted to examine the occurrence of groundwater encroachment into the crop root zone.

### 3.1.5 Geographic and Cartographic Features

This GIS data layer consists of highways, roads, streets, streams, rivers, county lines and irrigation networks for the project study area. U.S. Census Bureau TIGER/Line™ Files (Topologically Integrated Geographic Encoding and Referencing system) depict the basic 1990 Census geography including census tract and block boundaries, transportation routes, political boundaries and limited water features. TIGER files at a 1:100,000 scale were used for the three county area, i.e., Hidalgo, Cameron and Willacy Counties.

## 3.2 Climatic Database

Climatic data from various sources were compiled and stored in a SAS database (version 6.09, SAS Institute, Inc., Cary, North Carolina, USA) for use in the modeling analysis. Historical weather data for the Harlingen area were obtained from the National Climatic Data Center's (NCDC's) Summary of the Day West2 CD-ROM, (NOAA, 1993). The data set consists of daily minimum and maximum temperatures and accumulated daily rainfall for the Harlingen National Weather Service station.

Historical weather data for the period of record (1948-1992) contained on the CD-ROM were supplemented with data collected by the NRCS for a weather station located at the project's dryland demonstration site. In order to generate a continuous weather data set for the modeling analysis, missing data points were replaced by information collected at the closest station (NOAA, 1993-1996). The daily climatic dataset assembled for 1948-1997 represents (in order of preference) NRCS weather data collected at the dryland demonstration site, NCDC data for Harlingen, and NCDC data for Weslaco.

Based on discussions with TAEX experts, it was determined that the amount of pesticides applied to various crops within the study area would be influenced by climatic conditions due to an increase in pest pressure during wet years (Fipps, 1997a). For this reason, an analysis of annual precipitation was performed for the Harlingen area based on assembled data for the period of record from 1948 through 1996. Since rainfall data for 1997 constituted only a partial record it was not used in the climatic analysis. A frequency analysis of annual rainfall data for the 49-year period of record was performed to categorize years as either wet, dry or normal rainfall years. The analysis was performed based on rainfall during the growing season of crops grown in the study area. Classification of years into wet, dry and normal rainfall years was based on the following:

- Wet Year (accumulated rainfall during growing season > 75% quartile),

- Normal Year (25% quartile ≤ accumulated rainfall during growing season ≥ 75% quartile), and

- Dry Year (accumulated rainfall during growing season < 25% quartile).

For cotton, grain sorghum and corn, the growing season was defined as February through July. February was included as part of the growing season because the preplant soil moisture determines the need for a preplant irrigation of these crops. The classification scheme used to categorize the growing season (February- July) with respect to rainfall for these crops are as follows:

- Wet year > 379.9 mm of rain in growing season,

- Normal year receives between 186.5 mm and 379.9 mm of rain in growing season, and

- Dry year < 186.5 mm of rain in growing season.

For citrus and sugarcane, a 365-day growing season (January-December) was used to determine wet, dry and normal conditions. The classification scheme used to categorize the growing season with respect to rainfall for these crops are as follows:

- Wet year > 767.9 mm of rain in growing season,

- Normal year receives between 546.1 mm and 767.9 mm of rain in growing season, and

- Dry year < 546.1 mm of rain in growing season.

As a result of these analyses, a 24 year period extending from 1954 through 1977 was selected for the model application to the study area to estimate the benefits of BMP implementation. This shorter period reflected a frequency of wet, dry and normal years similar to the 49-year period of record. This information was also used to specify the crop management/pesticide applications under wet, dry and normal rainfall conditions with crop management varying on an annual basis depending on the rainfall condition. As EPIC limits the number of individual crop rotations within a given simulation run to 30, a 24-year simulation period was determined to be of sufficient length to compute average annual losses while accommodating the differing crop rotational patterns.

The results of climatic analysis are depicted in Figures 8 and 9. Monthly summaries of temperature minimum and maximums and rainfall for the selected simulation period (1954-1977) are included in Appendix C.

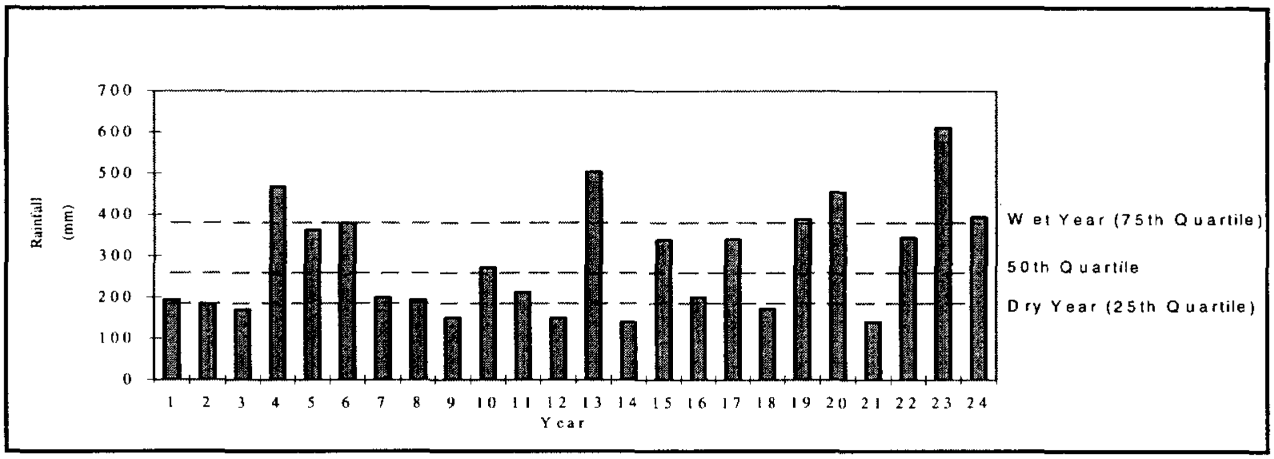



**Figure 8. Climatic Analysis of Harlingen Rainfall Data**
(24-Year Simulation Period, February - July Growing Season)

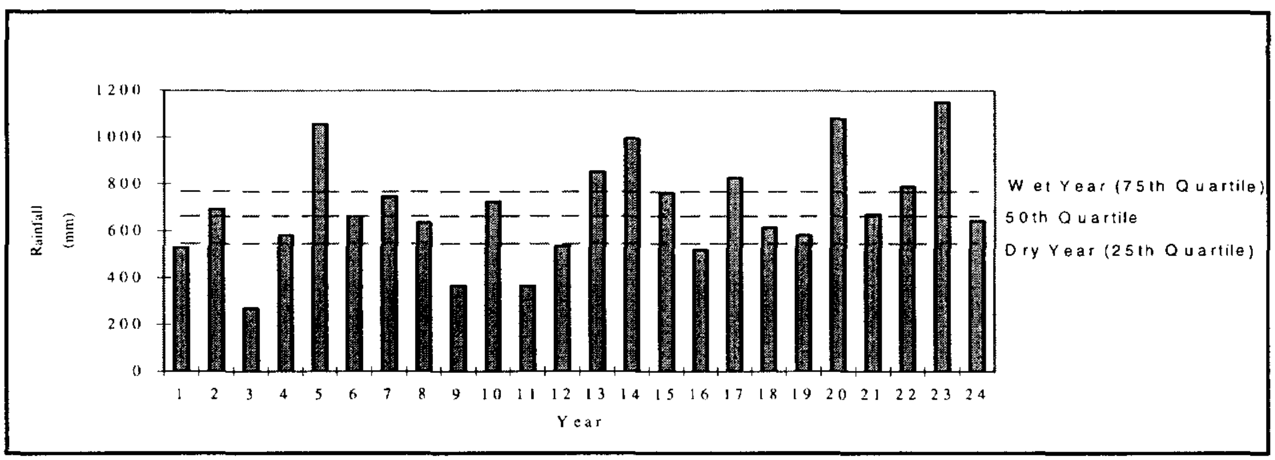



**Figure 9. Climatic Analysis of Harlingen Rainfall Data**
(24-Year Simulation Period, January - December Growing Season)

## 3.3 Water Quality Monitoring

Water samples were collected from the treated and control sides of both demonstration sites whenever runoff or subsurface drainage from the fields occurred. The orientation of demonstration sites and the location of sampling equipment are depicted in Figures 4 and 5, for the dryland and irrigated sites, respectively. Water quality monitoring was performed as specified in the USEPA-approved quality assurance project plan (TSSWCB, 1994 and 1997).

For the dryland site, surface runoff flowed down the furrows to the down slope border where it was diverted through a control structure to a drainage channel.

Two fabricated sharp-crested weirs were installed on site to measure flow. The level of water exiting the treatment and control sections of the field was monitored through the weirs. Pressure transducers connected to dataloggers recorded water level at the sites. Problems with the dataloggers installed at the treatment and control sections, however, limited the water level data available from the dryland site.

For the irrigated site, samples were collected following irrigation applications and rainfall events which resulted in subsurface drainage. The drainage system at the irrigated site (Figure 5) consisted of 10-centimeter (4-inch) corrugated polyethylene pipes with nylon sock filters. Each pipe was 366 meters (1200 feet) long and was buried at a depth of 1.7 meters (5.5 feet). The drainage lateral lines run east to west, 46 meters (150 feet) apart. Each lateral drains an area approximately 46 meters by 402 meters or 1.8 hectares (150 feet by 1320 feet or 4.4 acres). The lateral lines drain to a ditch on the western border which discharges to a constructed drainage channel. A single lateral line in the field was instrumented with automatic samplers. The two monitoring sites are not hydraulically distinct. The subsurface drainage from the BMP portion of the field, after being sampled, flows through the drain line under the control portion of the field before being discharged into the drainage ditch. During this time the drainage from the BMP portion may mix with drainage from the control portion and may be sampled again if the control sampler is triggered.

Automated water samplers (ISCO 3700)[1] were utilized to collect the water samples at both demonstration sites during the monitoring period which extended from April 1, 1996 through June 30. 1997. Each ISCO sampler was housed in a weatherproof, lockable instrument shelter to which a solar-powered battery was connected. The ISCO samplers were programmed to begin taking samples when moisture was detected by a level actuator. A datalogger, also housed within the shelter, recorded water levels within the subsurface drains at the irrigated sites and the depth of runoff through weirs at the outlet of the dryland sites. The original dataloggers installed at the demonstration sites were replaced with new Campbell Scientific, Inc. Model 21X dataloggers due to problems encountered early in the project.

Each ISCO sampler holds 12 liter-sized (0.264 gallon) glass sample bottles. Because pesticides were being analyzed, the sample bottles were glass, rather than plastic, were wrapped in foil to exclude light, and had Teflon-lined lids. The number of analyses performed on each sample required more than one liter of water; therefore, two bottles were required per sample. Thus, six samples could be obtained prior to refilling the sampler. The automatic samplers were programmed to take samples according to the regimes shown in Table 3.

[1] Mention or display of a trademark, proprietary product, or firm in the text or figures does not constitute an endorsement by TIAER, and does not imply approval to the exclusion of other suitable products or firms.

**Table 3. Automatic Sampling Regimes**

| Sample # | Dryland Site* | Irrigated Site* |
|---|---|---|
| 1 | 0.0 hours | 0.0 hours |
| 2 | 1.0 hours | 3.0 hours |
| 3 | 3.0 hours | 6.0 hours |
| 4 | 6.0 hours | 12.0 hours |
| 5 | 9.0 hours | 18.0 hours |
| 6 | 12.0 hours | 24.0 hours |

*All times referenced to a sampler activation time of 0.0 hours

The automatic samplers were inspected within 24 hours following rainfall events by representatives of the Southmost Soil and Water Conservation District. Water samples were preserved as necessary, sealed and labeled appropriately, packed in ice, and shipped to the TIAER laboratory for analysis. Chain-of-custody documentation was included, as required by the project's quality assurance project plan.

The TIAER laboratory, upon receipt of the samples, continued the appropriate chain-of-custody procedures, and took measures to meet holding times of the analytical procedures being performed. Table 4 lists the required container, preservation, and holding time for analysis of each parameter measured for this project.

**Table 4. Sample Collection, Preservation, and Holding Times**

| Parameter | Container | Preservation | Holding Time |
|---|---|---|---|
| Ammonia Nitrogen | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Nitrate-Nitrite Nitrogen | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Total Kjeldahl Nitrogen | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Orthophosphate Phosphorus | AW-GB | 4°C | 28 days |
| Total Phosphorus | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Total Suspended Solids | AW-GB | 4°C | 7 days |
| Chemical Oxygen Demand | AW-GB | pH<2 $H_2SO_4$, 4°C | 28 days |
| Azinphos (methyl) | AW-GT | 4°C * | 7 days ** |
| Malathion | AW-GT | 4°C * | 7 days ** |
| Parathion (methyl) | AW-GT | 4°C * | 7 days ** |
| Prometryn | AW-GT | 4°C * | 7 days ** |
| Atrazine | AW-GT | 4°C * | 7 days ** |
| Trifluralin | AW-GT | 4°C * | 7 days ** |
| Permethrin (cis/trans) | AW-GT | 4°C * | 7 days ** |

AW-GB=aluminum foil wrapped glass bottles
H2SO4=concentrated sulfuric acid
4°C= 4 degrees centigrade
AW-GT=aluminum foil wrapped glass with Teflon lined lid
* sodium thiosulfate must be added to 0.008% if sample contains chlorine residual
** 7 days until extraction, 40 days to analyze after extraction

The approved EPA method, estimated detection limit, and the equipment used for analysis of each parameter are listed in Table 5.

**Table 5. Laboratory Analytical Methods**

| Parameter | Method | Equipment Used | Estimated MDL * |
|---|---|---|---|
| Ammonia Nitrogen | EPA 350.1 | Perstorp Analytical Autoanalyzer | 0.037 mg/L |
| Nitrate-Nitrite Nitrogen | EPA 353.2 | Perstorp Analytical Autoanalyzer | 0.006 mg/L |
| Total Kjeldahl Nitrogen | EPA 351.1, EPA 351.2 | Perstorp Analytical Autoanalyzer with Tecator block digester | 0.194 mg/L |
| Orthophosphate Phosphorus | EPA 365.2 | Bechman DU64 Spectrophotometer | 0.010 mg/L |
| Total Phosphorus | EPA 365.4, EPA 365.2 | Perstorp Analytical Autoanalyzer with Tecator block digester | 0.101 mg/L |
| Total Suspended Solids | EPA 160.2 | Sartorius AC21P or Mettler AT261 | 10 mg/L |
| | | Analytical Balance, Oven | |
| Chemical Oxygen Demand | Hach 8000 | Hach DR 2000 | 6 mg/L |
| Azinphos (methyl) | EPA 1657 | Thermionic Bead Nitrogen - Phosphorus | 0.009 µg/L |
| Malathion | | Detector 5% carbowax packed primary | 0.011 µg/L |
| Parathion (methyl) | | with % carbowax Gas Chrom Q | 0.018 µg/L |
| Prometryn | | confirmation column | 0.020 µg/L |
| Trifluralin | EPA 1656 | Electron Capture Detector, DB-608 | 0.05 µg/L |
| Permethrin (cis/trans) | | primary column with a DB1701 | 0.02 µg/L |
| Atrazine | | confirmation column | 0.50 µg/L |

* MDL - Method Detection Limit, redetermined periodically.
MDLs determined October 1996
Pesticide MDLs determined September 1996

A water quality database for the project was maintained in SAS (version 6.09). This database contains the results of laboratory analyses conducted on water samples collected from the demonstration sites. The precision, accuracy, estimated practical quantity limits and data completeness for the TIAER chemistry laboratory can be found in the annual TIAER Laboratory Quality Assurance Reports, which are available from TIAER upon request. Copies of all raw data, laboratory analyses, documentation records, calibration logs, and other pertinent information are available for inspection upon request. All original data, both hardcopy and electronic forms, will be archived by TIAER for at least five years.

The number of events monitored for each of the demonstration sites during the study period (4/1/96 - 6/30/97) are listed in Table 6. The number of water samples collected and the timeframe of sampled events are also noted. A total of seven sampling events were monitored at the BMP portion of the irrigated demonstration site. Five of the seven sampling events (event numbers one, two, four, six and seven) represent subsurface drainage resulting from furrow irrigation. Two of the events (event numbers three and five) resulted from infiltration of rainfall at the site. The irrigated control site did not receive sufficient infiltration from event number three to trigger the sampler, so that site has data for only six events. Four rainfall runoff events were monitored at the dryland sites during the monitoring period.

Chemical constituent concentrations monitored during each of these events were used in model calibration. Water quality results are presented in this report as they relate to model calibration and testing. Results of laboratory analyses for individual samples are included in a companion report prepared by TAEX which also includes a qualitative analysis of the monitoring data for evaluation of BMP effectiveness.

**Table 6. Events Monitored at the Dryland and Irrigated Demonstration Sites**

| Site | Treatment | Sampling Event | Beginning Time of Sample Collection | Ending Time of Sample Collection | # of Water Samples Collected | Accompanying Flow Data Available |
|---|---|---|---|---|---|---|
| Irrigated | BMP | 1 | 4/15/96 4:00 | 4/16/96 4:00 | 3 | NO |
| | | 2 | 5/14/96 6:00 | 5/18/96 12:00 | 18 | NO |
| | | 3 | 6/24/96 17:00 | 6/24/96 17:00 | 1 | NO |
| | | 4 | 8/14/96 8:00 | 8/20/96 14:00 | 24 | NO |
| | | 5 | 8/26/96 18:00 | 8/30/96 14:00 | 22 | NO |
| | | 6 | 1/31/97 18:00 | 2/4/97 12:00 | 22 | NO |
| | | 7 | 6/13/97 18:00 | 6/15/97 14:00 | 11 | NO |
| Irrigated | Control | 1 | 4/16/96 4:00 | 4/17/96 4:00 | 3 | YES |
| | | 2 | 5/16/96 0:00 | 5/18/96 18:00 | 15 | YES |
| | | 3 | No samples were collected from control portion | | | |
| | | 4 | 8/18/96 16:00 | 8/21/96 14:00 | 14 | NO |
| | | 5 | 8/26/96 18:00 | 8/30/96 14:00 | 22 | NO |
| | | 6 | 1/29/97 18:00 | 2/2/97 12:00 | 22 | NO |
| | | 7 | 6/14/97 2:00 | 6/15/97 10:00 | 7 | NO |
| Dryland | BMP | 1 | 8/31/96 16:00 | 9/1/96 4:00 | 6 | NO |
| | | 2 | 9/27/96 23:00 | 9/28/96 1:00 | 2 | NO |
| | | 3 | 10/5/96 0:00 | 10/5/96 20:00 | 7 | NO |
| | | 4 | 3/11/97 9:00 | 3/11/97 13:00 | 3 | NO |
| Dryland | Control | 1 | 8/31/96 16:00 | 8/31/96 16:00 | 1 | NO |
| | | 2 | 9/27/96 23:00 | 9/28/96 1:00 | 2 | NO |
| | | 3 | 10/5/96 0:00 | 10/6/96 4:00 | 9 | NO |
| | | 4 | 3/11/97 8:00 | 3/11/97 8:00 | 1 | NO |

## 3.4 Characterization of Baseline Conditions

In preparation for the modeling assessment of BMP implementation, it was necessary to define the current conditions and crop management practices employed in the study area. Numerous assumptions were made based on discussions with experts familiar with local farming practices (Moore, 1997; Fipps, 1997b; Norman, 1997; Sauls, 1997; Sparks, 1997; Bremer, 1997; Rozeff, 1997). These assumptions were used to define current conditions as a baseline for BMP implementation comparisons. These assumptions are outlined in the following sections.

***Irrigation Practices.*** Several assumptions were made regarding irrigation methods for different types of irrigated crops. It was assumed that furrow irrigation with blocked ends is the most commonly used method of irrigating cotton, grain sorghum, corn and sugarcane crops in the study area. Flood irrigation or level border irrigation is the most prevalent method of irrigating citrus. A six-inch irrigation volume was assumed to be standard for furrow irrigation systems and a five-inch volume was assumed for flood irrigation. The number of applications per year varied based on the annual rainfall conditions and were defined for wet, dry and normal rainfall years. (See Table 9.)

***Crop Rotations.*** As stated earlier, it was assumed that 85 percent of the cotton produced in the area was rotated with grain sorghum and 15 percent was rotated with corn. These percentages were assumed for both irrigated and dryland cotton production. A two-year crop rotation was assumed for cotton with cotton being produced the first year and grain sorghum or corn the next, then alternating every year. Thus, for the 24-year simulation period, cotton production was simulated for 12 years, and either grain sorghum or corn for the alternate 12 years.

For sugarcane, a six year crop rotation was assumed. It was assumed that sugarcane would be planted the first year, followed by three years of ratoon cane. Cotton would be cultivated during the fifth and sixth years of the rotation, after which sugarcane would be planted again. Based on this crop rotation, 4 full rotations were simulated during the 24-year period. The modeling results represent simulations of 16 years of sugarcane production and 8 years of cotton production.

For citrus production, it was assumed that the trees were planted during the first year and began producing in the third year of a 24-year simulation period.

***Residue Management.*** In defining the current (baseline) conditions, it was assumed that crop residues from corn and grain sorghum crops were shredded and disked into the soil shortly after harvest. This practice was assumed to apply only to the corn and grain sorghum crops. Since mandatory plow down dates are set annually as a measure to control overwintering boll weevils, this practice is not applicable to the cotton rotation. Residue management is also not applicable to sugarcane production due to the method used to harvest sugarcane which involves burning of fields prior to harvesting of the cane.

***Fertilization.*** It was assumed that baseline crop fertilization occured as a single fertilizer application before or during planting with the amount based on anticipated yields and crop utilization without regard to soil nutrient levels. It was further assumed that fertilizer application rates would remain relatively constant from year to year. Annual fertilization rates assumed for baseline conditions are listed in Table 7.

**Table 7. Current Fertilization Practices**

| Crop | Management / Crop Stage | Yield Goal per Hectare (Acre) | Nitrogen N kg/ha (lb/ac) | Phosphorus $P_2O_5$ kg/ha (lb/ac) | Potassium $K_2O$ kg/ha (lb/ac) |
|---|---|---|---|---|---|
| Cotton | Irrigated | 1401 kg (2.5 bales) | 140 (125) | 90 (80) | 0 |
| | Dryland | 1121 kg (2.0 bales) | 112 (100) | 90 (80) | 0 |
| Grain Sorghum | Irrigated | 6727 kg 6000 lbs | 135 (120) | 90 (80) | 0 |
| | Dryland | 5605 kg(5000 lbs.) | 112 (100) | 67 (60) | 0 |
| Corn | Irrigated | 122 hl (140 bu) | 168 (150) | 90 (80) | 0 |
| | Dryland | 65 hl (75 bu) | 84 (75) | 67 (60) | 0 |
| Sugarcane | Plant Cane | 123,318 kg (55 tons) | 90 (80) | 49 (44) | 0 |
| | Ratoon Cane | 112,108 kg (50 tons) | 202 (180) | 0 | 0 |
| Citrus | See recommended rates for each year of growth in Table 8. | | | | |

hl=hectoliter

***Irrigation Land Leveling/Precision Land Forming.*** Based on discussions with local project participants during Technical Advisory Committe meetings, it was estimated that approximately 80 percent of the farmed soils in the study area have been leveled. This assumption was applied to both irrigated and dryland cotton in rotation with either grain sorghum or corn. It was also assumed that 80 percent of the sugarcane acreage had implemented irrigation land leveling. For citrus production under flood irrigation management, it was assumed that 100 percent of the acreage had been leveled prior to establishment of the orchard.

***Integrated Pest Management (IPM).*** As integrated pest management (IPM) practices have been promoted through educational programs of TAEX and other entities, it was necessary to determine the extent to which area producers were currently utilizing these practices. It was assumed that IPM was already being utilized in dryland agriculture because the profit margin is much narrower under dryland production requiring the farmer to pay particular attention to pesticide applications (Norman, 1997). Likewise, the practice of IPM has been quite common in citrus production for many years (Sauls, 1997). Therefore, the environmental benefits of IPM implementation on these areas have already been realized.

IPM implementation to sugarcane grown in the area is also not likely to yield much benefit. According to Norman Rozeff, agriculturist employed by the Rio Grande Valley Sugar Growers, Inc., insecticides are rarely applied to sugarcane grown in the Valley (Rozeff, 1997). Of the cropping systems evaluated, only irrigated cotton in rotation with either grain sorghum or corn is likely to show an environmental benefit from implementation of this BMP.

A survey of Texas cotton producers, conducted by Smith *et al.* (1996), compiled information on pesticide usage in the cotton industry. Survey results noted that the tactic ranked as the most important aspect of IPM is the practice of "scouting" acreage for the presence of insects, weeds, and disease. Survey results indicated that 99 percent of the cotton acreage in the Lower Rio Grande Valley (LRGV) was scouted, suggesting that some level of IPM was employed on almost all cotton acreage. Scouting was performed by farmers (34%), by dealers of farm supplies and/or chemicals (11%), and by consultants and specialists (50%) in the LRGV. Theory holds that pesticide application decisions are based on an economic threshold (ET), i.e., the point at which crops need treatment before pest populations cause economic crop loss, and scouting helps to determine the ET.

To determine the degree of IPM implementation by the area's cotton producers, participants in the Arroyo Colorado project evaluated the survey results as to which entity had performed the scouting. Although the survey results reported apply to the four county region comprising the LRGV, it was assumed these percentages are also representative of cotton production within the Arroyo Colorado Study Area and as such characterize the baseline conditions. The following percentages were assumed to represent baseline conditions for the irrigated cotton acreage in the Arroyo Colorado study area.

- Fully Implemented IPM Program 50%
- Mid-level IPM Program 45%
- Low-level IPM Program 5%

## 3.5 BMPs Evaluated

Through the project's technical advisory committee, BMPs suitable for crops grown in the study area were selected for evaluation. Six BMPs were selected for evaluation; however, some of the BMPs were not applicable to a particular crop or soil type. Assumptions regarding the BMPs selected and how each of the BMPs would be represented in the modeling analyses are discussed in the following sections.

### BMP #1 - Improved Nutrient Management

The first BMP evaluated was improved nutrient management. The primary difference between this BMP and the baseline condition is that fertilization rates would be based on soil test results with annual rates split into two applications rather than a single application. Annual fertilizer applications were based on expected yields and residual soil nutrient levels. Annual applications of nitrogen fertilizer to cotton, grain sorghum and corn crops were split, with one-half of the annual rate being applied during preplant or at planting and other one-half side-dressed approximately 30 days after planting. All of the phosphorus fertilizer requirement was applied in a single pre-plant application.

For flood-irrigated citrus, two-thirds of the annual nitrogen fertilizer requirement was applied in February and the remaining one-third was applied in May. For citrus groves utilizing microspray irrigation, it was assumed that liquid fertilizer was injected once per month, at the end of an irrigation application, with the annual fertilizer requirement reduced by 20 percent of that utilized by flood irrigated citrus.

Split nutrient applications are not recommended for sugarcane (Rozeff, 1997), however, soil testing would prove beneficial to sugarcane production. In simulating this BMP for sugarcane, fertilizer applications consisted of a single application with rates dependent on the stage of growth or ratoon cycle. The recommended fertilization rates used to simulated this BMP are listed in Table 8.

**Table 8. Recommended Fertilization Rates Under BMP #1 - Improved Nutrient Management**

| Crop | Management/ Crop Stage | Average Crop Yield/Hectare (Acre) | Nitrogen N kg/ha (lb/ac) | Phosphorus $P_2O_5$ kg/ha (lb/ac) ($P=P_2O_5 \times 0.44$) | Potassium $K_2O$ [1] kg/ha (lb/ac) |
|---|---|---|---|---|---|
| Cotton | Irrigated | 841 kg (750 lb. lint, 1.5 bales) | 67 (60) | 67 (60) | 0 |
| | Dryland | 561 kg (500 lb. lint, 1.0 bales) | 45 (40) | 45 (40) | 0 |
| Grain Sorghum | Irrigated | 5605 kg (5000 lb). | 112 (100) | 67 (60) | 0 |
| | Dryland | 4484 kg (4000 lb.) | 90 (80) | 45 (40) | 0 |
| Corn | Irrigated | 65 hl (75 bu) | 84 (75) | 67 (60) | 0 |
| | Dryland | 37 hl (42 bu) | 47 (42) | 67 (60) | 0 |
| Sugarcane | Plant Cane | 67,265 kg (30 tons) | 25 (22) | 83 (74) | 0 |
| | 1st Ratoon Cane | 67,265 kg (30 tons) | 112 (100) | 0 | 0 |
| | 2nd Ratoon Cane | 67,265 kg (30 tons) | 157 (140) | 0 | 0 |
| | 3rd Ratoon Cane | 67,265 kg (30 tons) | 168 (150) | 0 | 0 |
| Citrus | 1 yr. | - | 39 (35) | 0 | 0 |
| | 2 yr. | - | 56 (50) | 0 | 0 |
| | 3 yr. | 4,484-6,726 kg (2-3 tons) | 84 (75) | 0 | 0 |
| | 4 yr. | 11,211-13,453 kg (5-6 tons) | 112 (100) | 0 | 0 |
| | 5 yr. | 15,695-20,179 kg (7-9 tons) | 118 (105) | 0 | 0 |
| | 6 yr. | 22,422-31,390 kg (10-14 tons) | 123 (110) | 0 | 0 |
| | 7 yr. | 29,148-40,359 kg (13-18 tons) | 129 (115) | 0 | 0 |
| | 8 yr. | 33,632-44,843 kg (15-20 tons) | 140 (125) | 0 | 0 |
| | 9 yr. | 38,117-49,327 kg (17-22 tons) | 157 (140) | 0 | 0 |
| | 10+ yr. | 40,359-51,570 kg (18-23 ton)s | 168 (150) | 0 | 0 |

[1] Area soils are generally high in potassium, Potash is not applied
Rates should be reduced as appropriate based on soil test results

## BMP #2 - Improved Residue Management

Residue management is appropriate only for grain sorghum and corn crops. In simulating this BMP, it was assumed that crop residues left after harvesting of grain sorghum and corn crops were shredded and maintained on the surface of the field until seedbed preparation. The residue was plowed under and disked into the soil in December prior to bedding in preparation for cotton planting in the spring.

## BMP #3 - Improved Irrigation Water Management

It was assumed that improved irrigation water management, which consists of furrow irrigation, would result in the same number of irrigation applications with a reduction in irrigation volume from 152.4 mm (6 in.) per application to 101.6 mm (4 in.) per application (Fipps, 1997b). The number and volume of irrigations assumed for each crop are listed in Table 9.

**Table 9. Number and Volume of Irrigation Applications for Irrigation BMPs (BMP#3 and BMP #4)**

| Crop | BMP | Wet Year | | Normal Year | | Dry Year | |
|---|---|---|---|---|---|---|---|
| | | Number | Volume (mm) | Number | Volume (mm) | Number | Volume (mm) |
| Cotton | Baseline Condition/Furrow Irrigation | 2 | 152.4 | 4 | 152.4 | 6 | 152.4 |
| | Improved Irrigation Water Management | 2 | 101.6 | 4 | 101.6 | 6 | 101.6 |
| | Improved Irrigation Technology | 2 | 50.8 | 5 | 50.8 | 8 | 50.8 |
| Grain Sorghum / Corn | Baseline Condition/Furrow Irrigation | 0 | - | 2 | 152.4 | 3 | 152.4 |
| | Improved Irrigation Water Management | 0 | - | 2 | 101.6 | 3 | 101.6 |
| | Improved Irrigation Technology | 0 | - | 3 | 50.8 | 4 | 50.8 |
| Sugarcane | Baseline Condition/Furrow Irrigation | 4 | 152.4 | 8 | 152.4 | 10 | 152.4 |
| | Improved Irrigation Water Management | 3 | 101.6 | 7 | 101.6 | 9 | 101.6 |
| Citrus | Baseline Condition/Flood Irrigation | 4 | 127.0 | 5 | 127.0 | 6 | 127.0 |
| | Improved Irrigation Technology | Variable, weekly applications based on evapotranspiration | | | | | |

## BMP #4 - Improved Irrigation Technology

Improved irrigation technology includes surge flow irrigation of cotton, grain sorghum, and corn and microjet spray irrigation of citrus. Surge flow technology has not proven successful for sugarcane due to the large amounts of plant debris that accumulates in the cane furrows (Fipps, 1997b). The number and volume of irrigations assumed for each crop are also listed in Table 9.

The irrigation strategy used by microspray irrigators of citrus is usually determined by the estimated evapotranspiration rates for the LRGV area (Sauls, 1997). Timed weekly applications are made to citrus groves, provided no rainfall has occurred in the previous week. If rainfall occurs, citrus producers forego the scheduled weekly application until the following week. Based on information provided by Extension specialists the following weekly irrigation application rates were calculated as denoted in Table 10. The weekly applications were based on an assumed flow rate of 61 liters (16 gallons) per hour per tree for the microjet spray nozzles and an assumed tree spacing of approximately 59 trees per hectare (145 trees per acre).

**Table 10. Microspray Irrigation Schedule for Citrus**

| Month | Weekly Irrigation Timing | Weekly Irrigation Application |
|---|---|---|
| February and March | 8 hr/wk | 17.3 mm |
| April and May | 9 hr/wk | 19.6 mm |
| June | 10 hr/week | 21.6 mm |
| July | 11 hr/week | 23.9 mm |
| August | 12 hr/week | 26.2 mm |
| October and November | 11 hr/wk | 23.9 mm |

### BMP #5 - Irrigation Land Leveling/Precision Land Forming

Since partial implementation of this BMP has already been realized in the study area, this BMP was evaluated based on an increase in the percentage of leveled cropland in the study area from 80 percent to 95 percent.

### BMP #6 - Integrated Pest Management

This BMP, similar to land leveling practices, is in partial implementation in the study area. Based on baseline characterizations of IPM implementation, this BMP was evaluated through an increase in the cotton acreage under full implementation of IPM practices from 50 percent to 95 percent with 5 percent of the acreage remaining under a low-level IPM program.

Increased implementation of IPM from a mid-level to an almost fully implemented program on irrigated cotton acreage in rotation with either grain sorghum or corn, impacted roughly 58 percent of the study area on a bi-annual basis. Based on the crop management assumptions outlined for the baseline conditions, the modeled level of influence was limited to a reduction in the number of insecticide applications from 10 to 8 per year for the cotton rotation under normal rainfall conditions. Over the 24-year simulation period, this impacted 12 years, eliminating a total of 24 pesticide applications during this period.

This assessment, while addressing the benefits of increased implementation of IPM practices, has a very small impact on the total application of pesticides because the baseline condition already has a relatively high level of IPM implementation. During a normal year, this represents a 0.56 kg/ha (11%) reduction in pesticides applied to irrigated cotton from 4.96 kg/ha under a mid-level implementation to 4.40 kg/ha under the fully implemented program.

# 4.0 MODEL SELECTION AND TESTING

## 4.1 Model Selection

Three models were initially considered for evaluation of BMP effectiveness implemented throughout the Arroyo Colorado Project study area including DRAINMOD/CREAMS, EPIC-WT and the most recent version of EPIC, version 5300. The DRAINMOD/CREAMS model consists of DRAINMOD (version 4.6) linked with the CREAMS model and was developed by Parsons and Skaggs (1988) at North Carolina State University. The Erosion Productivity Impact Calculator - Water Table, EPIC-WT model, was developed by researchers at Louisiana State University (Sabbagh, *et al.*, 1991). The EPIC-WT model combines the EPIC model (version 3657) with a drainage model which utilizes the same approach as the DRAINMOD model. The Environmental Policy Integrated Climate, EPIC model (version 5300) is the most recent version of the field-scale model developed by the USDA-ARS at the Grassland, Soil and Water Research Laboratory, collocated with the Blackland Research Center in Temple, Texas (Mitchell *et al.*, undated).

Although the DRAINMOD/CREAMS and EPIC-WT models incorporate a more sophisticated drainage model and are capable of simulating the movement of nutrients and pesticides within the soil profile, the method used by these models to calculate tile flow rates is limited to flow resulting from high water table encroachment into the drain tiles. In the study area, however, flow in drain tiles can result from irrigation or rainfall events. Based on the application of Hooghoudt's steady state equation in DRAINMOD, the tile flow rate is set to zero when the water table is below the drainage depth even if sufficient precipitation or irrigation is applied to cause outflow through the tile drains. Deficiencies associated with the use of Hooghoudt's equation to predict subsurface tile flow (when water table depths are below the drainage depth) have been noted by several researchers (Sanoja, *et al.*, 1988; Kanwar, 1981; Rogers, 1985). This problem was observed during preliminary evaluation of the models based on test datasets generated for the Arroyo Project Area and was confirmed through conversations with model developers at Louisiana State University and North Carolina State University.

An additional drawback to these models is the limitation associated with crop growth, nutrient and pesticide components of the older versions of the USDA-ARS CREAMS and EPIC models. Modification and enhancement of the original CREAMS and GLEAMS models in the evolution of the current EPIC model and its multi-field version APEX have increased the level of sophistication of these models. Continual testing, development and refinement of these models by ARS researchers at the Grassland, Soil and Water Research Laboratory have led to increased capabilities and improved accuracy compared to earlier versions. Enhancements of the EPIC/APEX models since the release of CREAMS and EPIC (version 3657) include an improved crop growth model, upgrade of the pesticide model components, the addition of ammonia volatilization subroutines, new erosion equations and the addition of TR-55 peak rate estimator.

Given the limitations of the DRAINMOD/CREAMS and EPIC-WT models and the fact that BMPs selected for evaluation relate to management and conservation practices rather than the structural design of tile drainage system (e.g., tile spacing, placement, depth, etc.), it seems appropriate to base model selection on the level of sophistication of the crop growth/management components of the model rather than the drainage components. EPIC (version 5300) while utilizing simplified drainage calculations, has been extensively tested and validated in many areas of the nation. Performance testing of EPIC's crop growth components as well as the hydrology, nutrient and pesticide subroutines have indicated that EPIC performs well even with limited calibration. For these reasons, EPIC5300 was selected for use in evaluating the effects of BMP implementation within the Arroyo Colorado study area.

## 4.2 Model Calibration/Sensitivity Analysis

Model calibration was performed through comparisons of model predictions to measured data collected at the irrigated and dryland demonstration sites. Available crop management data (tillage and harvest dates, fertilization, irrigation, and pesticide applications) for activities during the study period were obtained from NRCS and Agro-Synergetics, Inc. All available weather and water level data for the demonstration sites were also obtained from NRCS. Based on acquired information, input datasets for the EPIC model were generated to characterize grain sorghum and cotton production during the 1996 and 1997 growing seasons. EPIC datasets for the demonstration sites are included in Appendix D. Daily weather data and hourly water level data utilized for model calibration are included in Appendices E and F, respectively.

Water level data collected by NRCS was converted to flow based on the following equations supplied by NRCS:

$$D = \frac{d - 4.11''}{12}$$

$$Q = 0.1015\sqrt{D}$$

where

$D$ = depth of water in the drain in feet,

$d$ = the water level recorded by datalogger in inches, and

$Q$ = drain flow in cfs.

The hourly drain flow calculated was converted to metric units ($m^3/s$) and accumulated on a daily basis for comparison to daily drain flow predicted by the EPIC model.

Illustrated in Figure 10 is a comparison of subsurface drain flow predicted by EPIC for the irrigated demonstration site to that measured during the two irrigation events for which flow data were available.

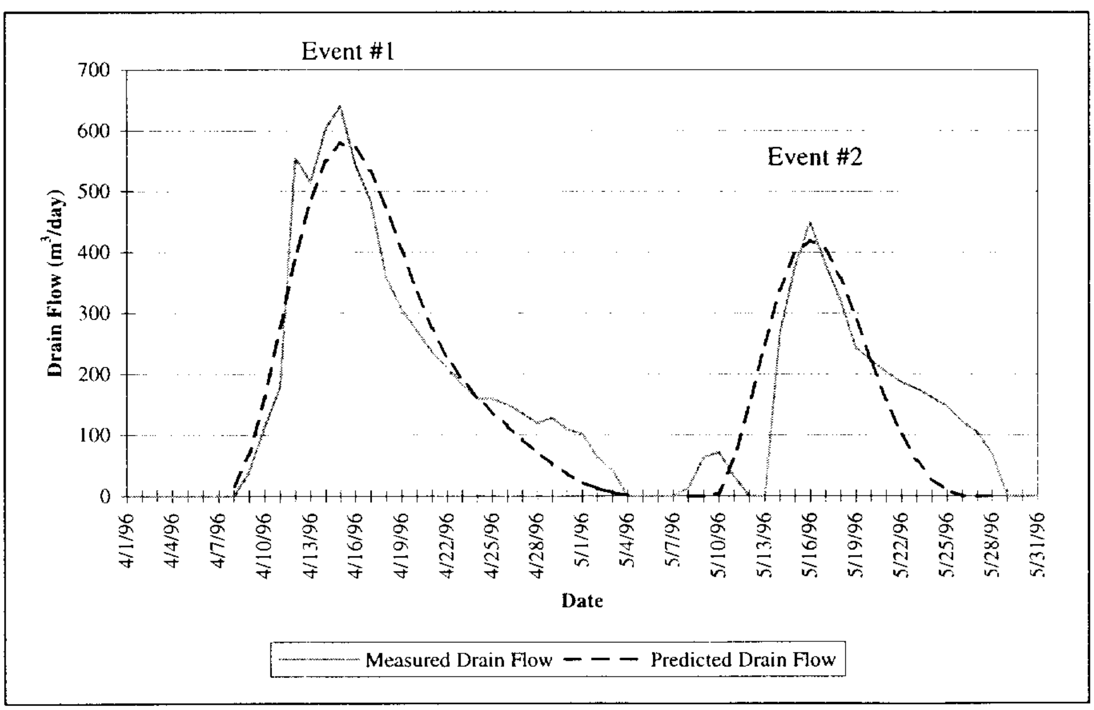



**Figure 10. Comparison of Predicted to Measured Subsurface Drain Flow at the Irrigated Demonstration Site**

The results indicate good correspondence between the subsurface drain flow predicted by the calibrated EPIC model and the measured data observed for two irrigation events at the irrigated control site. Comparisons of drained volume and soluble nitrogen loads for each event also yielded good correspondence as indicated in Table 11. For event number one, EPIC predicted a drain volume of 6,251 cubic meters compared to 6,412 cubic meters which was computed based on water level measurements in the drain. The soluble nitrogen load predicted by EPIC for the event was 97 kilograms compared to 98 kilograms computed from the flow and constituent concentration data.

For event number two, close agreement between the predicted and measured drain volume was observed. EPIC predicted a drain volume of 3,247 cubic meters which compares well with the computed drain volume of 3,611 cubic meters. The soluble nitrogen load predicted by EPIC for event number 2 was slightly greater (53 kilograms) than the 44 kilograms calculated based on the monitoring data.

**Table 11. Comparison of Predicted to Measured Subsurface Data for the Irrigated Demonstration Site**

| | Measured | Predicted |
|---|---|---|
| Event # 1<br>4/8/1996 12:02:00 AM - 5/4/1996 11:02:00 PM | | |
| Drain Volume (cubic meters) | 6,412 | 6,251 |
| Mass of Soluble N (kg) | 98 | 97 |
| Event # 2<br>5/8/1996 12:02:00 AM - 5/28/1996 11:02:00 PM | | |
| Drain Volume (cubic meters) | 3,611 | 3,247 |
| Mass of Soluble N (kg) | 44 | 53 |

Since accompanying flow data were not available for sampling events three through seven at either the BMP or control sections of the irrigated demonstration site, model testing for these events was limited to comparisons of soluble nitrogen concentrations predicted by the EPIC model to measured concentrations of soluble nitrogen. For both the BMP and control sites, the predicted and measured soluble nitrogen concentrations in the drain flow were plotted over time (Figures 11 and 12).

Comparisons were made for two time periods. Figures 11 a) and 12 a) examine a two-month period from April 1, 1996 through May 31, 1996 for the grain sorghum rotation. Measured data represent concentrations observed in subsurface drainage following two irrigation events. Geometric mean daily concentrations were computed from sample concentrations for comparison to daily predicted values. Figures 11 b) and 12 b) depict a three-month period from January 1, 1997 through March 31, 1997. This timeframe depicts measured and predicted soluble nitrogen concentrations for the 1997 pre-plant period for the cotton rotation. This period primarily encompasses irrigation and fertilizer applications prior to planting of the cotton crop on March 20, 1997 with measured data representing subsurface drain concentrations during a single pre-plant irrigation event. As can be seen in Figures 11 and 12, concentrations of soluble nitrogen predicted by the EPIC model generally are within the range of values observed in the monitoring data.

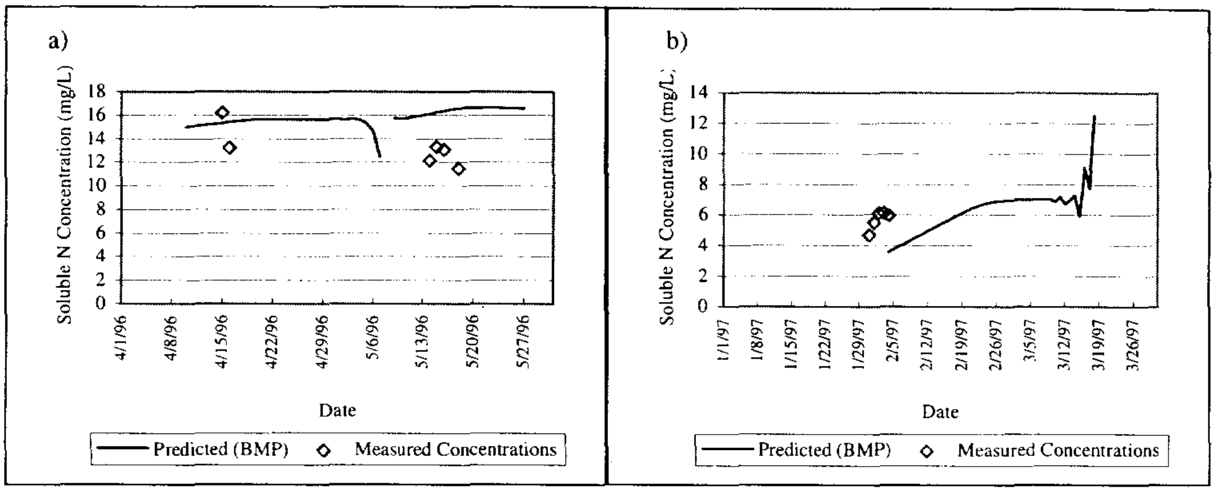



**Figure 11. Soluble Nitrogen Concentrations Predicted for Subsurface Drain Flow, Irrigated BMP Site**
a) 4/1/96 - 5/31/96 b) 1/1/97 - 3/31/97

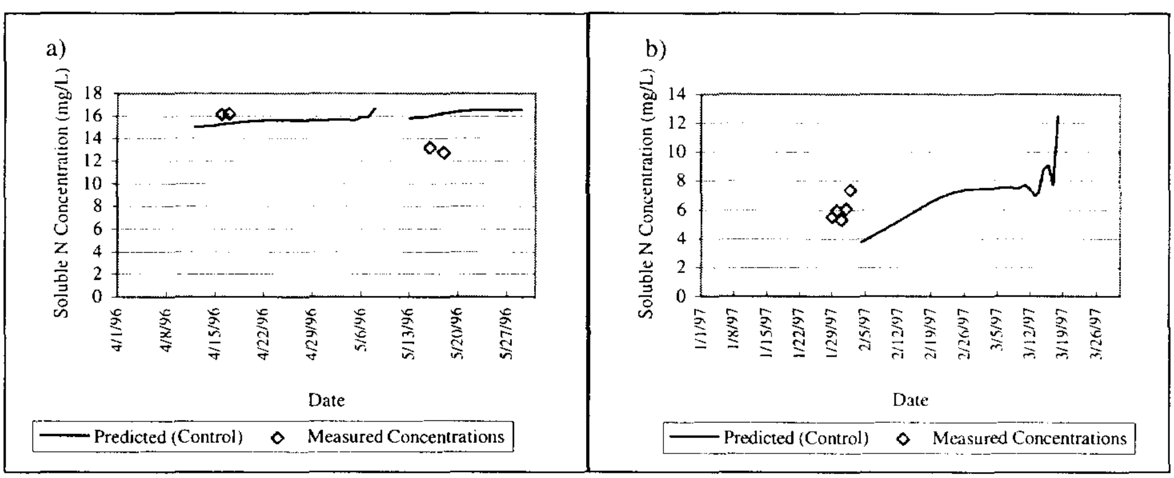



**Figure 12. Soluble Nitrogen Concentrations Predicted for Subsurface Drain Flow, Irrigated Control Site**
a) 4/1/96 - 5/31/96 b) 1/1/97 - 3/31/97

The limited amount of water level data available for the demonstration sites precluded an exhaustive calibration of the EPIC model. Calibration was performed for the irrigated demonstration site based on data collected during the first two irrigation events for which accompanying flow data was available.

Without accompanying flow data for the runoff events monitored at the dryland site, attempts to calibrate the controlling input variables to more closely correlate predicted concentrations with observed values was not possible. A cursory comparison of predicted concentrations to those observed at the demonstrations sites was performed. The model output including predicted flow, concentrations and crop yields were inspected for reasonableness based on "best professional judgment." If the predicted results appeared to be reasonable, i.e., displaying an acceptable range of values, no further adjustments were made. If input adjustments were deemed necessary, initial soil moisture or runoff curve numbers were modified to predict flow (runoff or subsurface drainage) that corresponded more closely with the timing of observed flow events.

Due to a lack of site specific rainfall data for the dryland site beyond February 1997, comparisons of predicted to measured concentrations for the dryland demonstration sites were conducted for a shorter period, extending from April 1, 1996 through March 31,1997. As a check of model fidelity, predicted and measured concentrations were compared. For several important water quality parameters, geometric mean concentrations computed based on measured and predicted data for corresponding time periods are listed in Table 12. Measured data from runoff events one through three were used for comparisons. The results indicated that the mean concentrations predicted by EPIC were comparable to those computed from observed data. With the exception of organic and total nitrogen, the predicted concentrations were slightly higher that those observed. Predicted organic and total nitrogen concentrations were slightly lower than measured values. Overall, the concentrations predicted by EPIC for these comparisons were considered to be within acceptable ranges and, given the limited calibration that was possible, provided reasonable estimates of nutrient and sediment concentrations in surface runoff from the dryland demonstration site.

**Table 12. Measured and Predicted Geometric Mean Concentrations in Surface Runoff from the Dryland Demonstration Site**

| Constituent (units) | BMP Site | | Control Site | |
|---|---|---|---|---|
| | Measured | Predicted | Measured | Predicted |
| Soluble N in Surface Runoff (mg/L) | 0.220 | 0.567 | 0.243 | 0.580 |
| Organic N in Surface Runoff (mg/L) | 1.865 | 1.008 | 1.928 | 1.606 |
| Total N in Surface Runoff (mg/L) | 2.156 | 1.585 | 2.225 | 2.198 |
| Soluble P in Surface Runoff (mg/L) | 0.349 | 0.511 | 0.316 | 0.549 |
| Organic P in Surface Runoff (mg/L) | 0.860 | 0.917 | 0.727 | 1.413 |
| Total P in Surface Runoff (mg/L) | 1.357 | 1.764 | 1.243 | 1.986 |
| Sediment Concentration in Surface Runoff (mg/L) | 488 | 522 | 586 | 735 |

A sensitivity analysis was also completed for key input parameters to the EPIC model using the datasets developed for the demonstration sites. The sensitivity of model output to the runoff curve number (EPIC variable CN2), initial nitrate concentration in the soil (EPIC variable WNO3), and the time required for the drainage system to reduce plant stress (EPIC variable DRT) was determined. These key calibration parameters were selected based on a sensitivity analysis performed on an earlier release of EPIC5300 (Chung and Gu, 1997) and discussions with model developers at the Blackland Research Center. Results of the sensitivity analysis, included in Appendix G, aided in the calibration of EPIC for the two events monitored at the irrigated control site. The values for DRT used in the model application were determined through the model calibration process. A DRT value of 3.5 days yielded the best correspondence with measured drain flow for calibration events number one and two.

As noted by Chung and Gu (1997), calibration of initial nitrate nitrogen concentration (WNO3) in the soil improves model predictions for the first year of the simulation but has little effect on subsequent years. Measured soil nitrogen levels were used for model calibration based on soil samples collected at the demonstration sites. In applying the EPIC model for long-term simulations of the study areas, initial soil nutrient levels were estimated based on program defaults.

While minor adjustments in the runoff curve number (CN2), within the published range for the soil and crop category, were made for calibration of the EPIC model to specific conditions at the BMP demonstration sites, no attempts were made to adjust the selected curve numbers used in model applications. Curve numbers used in application runs were selected from standard tables published by the NRCS (USDA-SCS, 1972, 1986). NRCS project participants provided assistance in selection of runoff curve numbers based on their knowledge of local soil and crop conditions.

# 5.0 EVALUATION OF BMP IMPLEMENTATION

Through the project's technical advisory committee, BMPs suitable for crops grown in the study area were selected for evaluation. Evaluation of the environmental impacts of BMP implementation for the study area was performed based on a modeling analysis. The methodology used for these evaluations are documented in the following sections.

Input datasets characterizing crop production areas within the Arroyo Colorado study area were developed with the assistance of extension specialists at the TAMU Research and Extension Center in Weslaco, who provided information on pesticide use in Cameron County including typical timing and application rates for the crops of interest. Representative crop management schedules developed for the modeling analyses are included in Appendix H. Assumptions relating to BMP implementation within the watershed were also defined and are included in Appendix I. Pesticides which were identified in the representative crop management schedules included 10 herbicides, 13 insecticides and 2 defoliants. The specific pesticides considered in the modeling analysis of BMPs are listed in Table 13.

**Table 13 . List of Pesticides Considered in the Modeling Analysis**

| | Common Name | Trade Name | | Common Name | Trade Name |
|---|---|---|---|---|---|
| HERBICIDES: | * Atrazine | Aatrex | INSECTICIDES: | Benomyl | Benlate |
| | Dicambra Soluble Salt | Banvel | | Dicrotophos | Bidrin |
| | Ametryn | Evik | | * Azinphos-methyl | Guthion |
| | Bromacil | Hyvar X | | Cyhalothrin | Karate |
| | Simazine | Princep | | Dicofol | Kelthane |
| | Pendmimethalin | Prowl | | Copper hydroxide | Kocide |
| | * Trifluralin | Treflan | | Chlorpyrifos | Lorsban |
| | Glyphosate amine | Roundup | | Acephate | Orthene |
| | Oryzalin | Surflan | | * Permethrin | Pounce |
| | Norflurazon | Evital/Solicam | | Aldicarb | Temik |
| | | | | Fenbutatin oxide | Vendex |
| DEFOLIANTS: | Tribufos | DEF | | Oxamyl | Vydate |
| | Thidiazuron | Dropp | | Petroleum Oil Spray | |

* Monitored at Demonstration Fields

Model simulations were performed for each of the crop/soil/BMP combinations. Average annual loads of nutrients and pesticides were calculated for the study area based on the modeling results. In calculating load reductions for the study area, individual pesticide loads were summed representing a total pesticide load. Percent reductions of surface, subsurface and total constituent losses were estimated for each of the six BMPs evaluated. Also evaluated was the condition in which all of the applicable BMPs were implemented within the study area. Percent change for the study area was calculated as:

$$\frac{L(ABI) - L(BC)}{L(BC)} \times 100$$

Where:

$L(ABI)$ = Total constituent load after BMP implementation, and

$L(BC)$ = Total constituent load at baseline condition.

Results of BMP evaluations (Table 14) indicated significant reductions in nutrient and pesticide loads from implementation within the study area. Percent reductions in total nitrogen loads exceeding 30 percent were estimated for improved nutrient management, improved irrigation water management and improved irrigation technology. Improved nutrient management also had the greatest impact on total phosphorus loads with an estimated 15 percent reduction attributed to this BMP. With respect to pesticide and sediment losses from cropland areas, the two BMPs dealing with irrigation practices (improved irrigation water management and improved irrigation technology) showed the greatest potential for reducing contributions from the study area. Based on the modeling analysis, BMP number 2, improved residue management, displayed only minor reductions in nutrient loads but effected an estimated 18 percent reduction in sediment loss due to water erosion. Improved nutrient management resulted in an estimated 34 percent reduction in total nitrogen losses and an estimated 15 percent reduction in total phosphorus; however, it showed no change in pesticide contributions.

**Table 14. Percent Change[1] Associated with BMP Implementation in the Arroyo Colorado Study Area**

| BMP | Nitrogen Losses | | | Phosphorus Losses | Pesticide Losses | | | Sediment Loss Due to Water Erosion |
|---|---|---|---|---|---|---|---|---|
| | Surface | Subsurface | Total | Total | Surface | Subsurface | Total | |
| BMP# 1 - Improved Nutrient Management | -5 | -40 | -34 | -15 | 0 | 0 | 0 | 0 |
| BMP# 2 - Improved Residue Management | -4 | 0 | 0 | -2 | -13 | 0 | -8 | -18 |
| BMP# 3 - Improved Irrigation Water Management | -2 | -36 | -30 | -4 | -28 | -33 | -30 | -30 |
| BMP# 4 - Improved Irrigation Technology | 4 | -56 | -45 | -5 | -31 | -22 | -28 | -43 |
| BMP# 5 - Increase in Irrigation Land Leveling/Precision Land Forming to 95% | -9 | 2 | 0 | -5 | -8 | 1 | -5 | -21 |
| BMP# 6 - Increase in IPM Implementation to 95% | 0 | 0 | 0 | 0 | -1 | 0 | -1 | 0 |
| Implementation of all applicable BMPs | -21 | -76 | -64 | -27 | -78 | -28 | -62 | -62 |

[1]Negative values represent a percent decrease in the constituent, whereas a positive value represents a percent increase.

Although BMPs number 5 and 6, dealing with land leveling practices and integrated pest management (IPM) practices, both displayed rather minor reductions in constituent loads, it should be kept in mind that these practices are largely implemented under the baseline condition, and this evaluation merely dealt with increasing the implementation in each case to 95 percent. It cannot and should not be concluded that these BMPs are not successful in reducing nonpoint pollution, but rather than much of the environmental benefits associated with these BMPs has already been realized. It would appear that educational and planning efforts by TAEX, NRCS, TSSWCB and other organizations in promoting integrated pest management and land leveling practices have been largely successful in effecting implementation among area producers.

Relatively low pesticide reductions were predicted for BMP number 6, i.e., increased IPM implementation, because a high level of IPM implementation is already occurring. However, the actual environmental benefits associated with these practices may be demonstrated by the differences in surface and subsurface pesticide losses predicted for a single field under the low and full implementation schemes. The average annual pesticide loss predicted for surface runoff from a cotton-grain sorghum rotation on a soil representative of Group 2 decreased from 5.9 g/ha under a low-level IPM program to 4.4 g/ha under the full implemented IPM program. Similarly, the subsurface pesticide losses decreased from 3.4 g/ha to 0.01 g/ha.

The evaluation considering implementation of all applicable BMPs to cropland within the study area displayed percent reductions ranging from 21 percent to 78 percent. Percent reductions estimated for total nitrogen, pesticide and sediment losses exceeded 60 percent for all BMPs combined.

# 6.0 REFERENCES


Baumer, O., P. Kenyon, and J. Bettis. 1997. Map Unit Use File (MUUF), version 2.14 User's Manual.

Bremer, J. 1997. Personal communication (telephone conversation, September 2, 1997). Professor and Extension Weed Control Expert, Texas A&M University System, Corpus Christi, Texas

Brown, L.F., J.L. Brewton, T.J. Evans, J.H. McGowen, W.A. White, G.G. Groat, and W.L. Fisher. 1980. Environmental Geologic Atlas of the Texas Coastal Zone - Brownsville-Harlingen Area. Bureau of Economic Geology, The University of Texas at Austin. Austin, Texas.

Chung, S.; and R. Gu. 1997. Project Progress Report for Evaluating EPIC Model Performance for Iowa. Department of Civil and Construction Engineering, Water Resources/Environmental Engineering Division, Iowa State University, Ames, Iowa.

Fipps, G. 1996. Analysis of the Arroyo Colorado Water Quality Database, Progress Report, Long-term Trends of Water Quality Indicators. Texas Agricultural Extension Service, Texas A&M University System, College Station, Texas.

Fipps, G. 1997a. Personal interview, June 13, 1997. Extension Specialist, Texas Agricultural Extension Service, Texas A&M University, College Station, Texas.

Fipps, G. 1997b. Personal communication (fax received July 21, 1997). Extension Specialist, Texas Agricultural Extension Service, Texas A&M University, College Station, Texas.

Kanwar, R.S. 1981. Hydrologic Simulation of Nitrate Losses with Tile Drainage Water. Ph.D. dissertation, Agricultural Engineering Department, Iowa State University, Ames, Iowa.

Mitchell, G., R.H. Griggs, V. Benson, and J.R. Williams. Undated. The EPIC Model Environmental Policy Integrated Climate. Texas Agricultural Experiment Station Blackland Research Center, USDA Agricultural Research Service Grassland, Soil and Water Research Laboratory, and USDA Natural Resource Conservation Service. (Draft Version 5300.) Temple, Texas.

Moore, A. 1997. Personal interview, June 6, 1997. Engineer, United States Department of Agriculture-Natural Resource Conservation Service, San Benito, Texas.

NOAA. 1993-1996. National Oceanic and Atmospheric Administration, National Climatic Data Center. Climatological Data Annual Summary. Volumes 98-101. US Department of Commerce. Asheville, North Carolina.

NOAA. 1993. National Oceanic and Atmospheric Administration, National Climatic Data Center. NCDC Summary of the Day WEST2. EarthInfo Inc., Boulder, Colorado.

Nordstrom, P.L., and R. Quincy. 1993. UM-50 Ground-Water Data System Data Dictionary. Texas Water Development Board. Austin, Texas.

Norman, J. 1997. Personal interview, June 4, 1997 and August 29, 1997. Extension Agent-IPM, Texas Agricultural Experiment Station, Research and Extension Center, Weslaco, Texas.

Parsons, J.E. and R.W. Skaggs. 1988. Water Quality Modeling with DRAINMOD and CREAMS. ASAE Paper No. 88-2569. St. Joseph, MI: ASAE.

Rozeff, N. Personal interview. August 29, 1997. Agriculturist. Rio Grande Valley Sugar Growers, Inc., W.R. Cowley Sugar House, Santa Rosa, Texas.

Rogers, J.S. 1985. Water Management Model Evaluation for Shallow Sandy Soils. Transactions of the ASAE. 28(3): 785-794.

Sabbagh, G.J., R.L. Bengtson, and J.L. Fouss. 1991. Modification of EPIC to Incorporate Drainage Systems. Transactions of the ASAE. Vol. 34(2):467-472.

Sanoja, J., Kanwar, R.S. and S.W. Melvin. 1988. Evaluation and Testing of DRAINMOD for Iowa Soils. Paper no. MCR-88-134. American Society of Agricultural Engineers, 1988 Mid-Central Region Meeting, April 8-9, 1988, Columbia, MO.

Sauls, J. Personal interview. August 29, 1997. Extension Horticulturist (Citrus), Texas Agricultural Experiment Station, Research and Extension Center, Weslaco, Texas.

Smith, D., T. Fuchs, and R. Holloway. December 1996. Cotton Pests, Pesticide Use & Related Management Practices By Texas Growers. National Agricultural Pesticide Impact Assessment Program CREES/ USDA. Project No. 94-EPIX-1-0192.

Sparks, A.N., Jr. 1997. Personal Interview. August 29, 1997. Extension Entomologist, Texas Agricultural Experiment Station, Research and Extension Center, Weslaco, Texas.

Stichler, C., G. Fipps. 1997. Irrigated Grain Sorghum Production. Texas Agricultural Extension Service, Texas A&M University System, College Station, Texas.

Texas Agricultural Statistics Service. 1996. Texas Agricultural Statistics 1995. U.S. Department of Agriculture and Texas Department of Agriculture. (Bulletin 254.) Austin, Texas.

TDWR. 1984. Texas Department of Water Resources. Water for Texas. Technical Appendix, Volume 2. (GP-4-1) Austin, Texas.

TSSWCB. 1997. Texas State Soil and Water Conservation Board. Quality Assurance Project Plan for the Environmental Measurement Activities Relating to Arroyo Colorado NPS Project Located in Cameron County, Texas. Annual Update to the Quality Assurance Management Plan (Q-97-102), January 1997. Submitted to EPA June 24, 1997 Temple, Texas.

TSSWCB. 1994. Texas State Soil and Water Conservation Board. Quality Assurance Project Plan for the Environmental Measurement Activities Relating to Arroyo Colorado NPS Project Located in Cameron County, Texas. Temple, Texas.

TNRCC. 1994a. Texas Natural Resources Conservation Commission. 1994 Regional Assessment of Water Quality in the Rio Grande Basin. Austin, Texas.

TNRCC. 1994b. Texas Natural Resources Conservation Commission. 1994 State of Texas Water Quality Inventory. Austin, Texas.

TNRCC. 1996. Texas Natural Resources Conservation Commission. 1996 State of Texas Water Quality Inventory. Austin, Texas.

TNRCC. 1997. Texas Natural Resources Conservation Commission. 303(d) Action/TMDL 1996 Master List (Draft). Austin, Texas.

TWC. 1989a. Texas Water Commission. Groundwater Quality of Texas—An Overview of Natural and Man-Affected Conditions. Austin, Texas.

TWC. 1989b. Texas Water Commission. Results of Intensive Priority Pollutant Monitoring in Texas - Phase II. (LP 89-07). Austin, Texas.

TWC & TSSWCB. 1991. Texas Water Commission and Texas Natural Resources Conservation Commission. 1990 Update to the Nonpoint Source Water Pollution Assessment Report for the State of Texas. Austin, Texas.

TWDB. 1991. Texas Water Development Board. Surveys of Irrigation in Texas—1958, 1964, 1969, 1974, 1979, 1984, and 1989. (Report 329) Austin, Texas.

Twidwell, S.R. 1978. Intensive Surface Water Monitoring Survey for Segment 2201, Arroyo Colorado Tidal. Texas Department of Water Resources. (IMS-72). Austin, Texas.

U.S. Army. 1988. GRASS Reference Manual. USA CERL. Champaign, Illinois.

USACE. 1990a. United States Army Corps of Engineers. Cameron County, Texas (Flood Damage Prevention) Feasibility Report. File # RIO 904-18. Galveston, Texas.

USACE. 1990b. United States Army Corps of Engineers. GIS land use data layer developed for #RIO 904-18 project report. Unpublished data, available upon request from USACE, Galveston Office.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1983. Lower Rio Grande Plain Irrigation Guide. In-house document, June 1983. San Benito, Texas.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1982. Technical Notes.

U.S. Department of Agriculture, Soil Conservation Service. May 1977. Soil Survey of Cameron County, Texas.

U.S. Department of Agriculture, Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds. Technical Release 55; USDA, Soil Conservation Service, Engineering Division; Second Edition, June 1986, Table 2-2b. Runoff curve numbers for cultivated agricultural lands, p. 2-6.

U.S. Department of Agriculture, Soil Conservation Service. 1972. National Engineering Handbook: Section 4, Hydrology. Washington, DC.

U.S. Department of Commerce. 1992. Census of Agriculture 1992. Geographic Area Series (CD-ROM Data Files 1B, 1C). Economics and Statistics Administration, Bureau of the Census, Washington, DC.

Williams, J.R. 1995. The EPIC Model. In: Computer Models of Watershed Hydrology, (Ed. V.P. Singh), Water Resources Publications, Highlands Ranch, Colorado.

# APPENDIX A

## General Soil Categories Defined for the Arroyo Colorado Project

| General Soil Category[1] | Soil Intake Curve [2] (Inches/hour) | Slope Range (%) | Average Slope (%) | Soil Mapping Unit |
|---|---|---|---|---|
| 1 | < 0.06 | 0 - 1 | 0.50 | BE - Benito clay |
| | | 0 - 1 | 0.50 | GR - Grulla clay |
| | | 0 - 1 | 0.50 | HA - Harlingen clay |
| | | 0 - 1 | 0.50 | HC - Harlingen clay, saline |
| | | 0 - 1 | 0.50 | MEA - Mercedes clay, 0 to 1 percent slope |
| | | 1 - 3 | 2.00 | MEB - Mercedes clay, 1 to 3 percent slope |
| | | 1 - 5 | 3.00 | MGC - Mercedes clay, loamy substratum, 1 to 5 percent slope |
| | | 0 - 1 | 0.50 | OR - Orelia clay loam, clayey subsoil variant |
| 2 | 0.3 | 0 - 1 | 0.50 | CE - Cameron silty clay |
| | | 0 - 1 | 0.50 | MA - Matamoros silty clay |
| | | 0 - 1 | 0.50 | MC - Matamoros-Rio Grande complex |
| | | 0 - 1 | 0.50 | OM - Olmito silty clay |
| | | 0 - 1 | 0.50 | RE - Raymondville clay loam |
| | | 0 - 1 | 0.50 | RG - Raymondville clay loam, saline |
| | | 0 - 1 | 0.50 | RO - Rio clay loam |
| 3 | 0.5 | 0 - 1 | 0.50 | CA - Camargo silt loam |
| | | 0 - 1 | 0.50 | CC - Camargo silty clay loam |
| | | 0 - 1 | 0.50 | LAA - Laredo silty clay loam, 0 to 1 percent slopes |
| | | 0 - 3 | 2.00 | LAB - Laredo silty clay loam, 1 to 3 percent slopes |
| | | 0 - 1 | 0.50 | LC - Laredo silty clay loam, saline |
| | | 0 - 1 | 0.50 | LD - Laredo-Olmito complex |
| | | 0 - 1 | 0.50 | LEA - Laredo-Reynosa complex, 0 to 1 percent slopes |
| | | 1 - 3 | 2.00 | LEB - Laredo-Reynosa complex, 1 to 3 percent slopes |
| 4 | 0.5 | 0 - 1 | 0.50 | HGA - Hidalgo fine sandy loam, 0 to 1 percent slopes |
| | | 1 - 3 | 2.00 | HGB - Hidalgo fine sandy loam, 1 to 3 percent slopes |
| | | 0.2 - 0.3 | 0.25 | HO - Hidalgo sandy clay loam |
| | | 0.3 - 0.5 | 0.40 | LY - Lyford sandy clay loam |
| | | 0.1 - 0.2 | 0.15 | RA - Racombes sandy clay loam |
| 5 | 0.5 | 0 - 1 | 0.50 | WAA - Willacy fine sandy loam, 0 to 1 percent slopes |
| | | 1 - 3 | 2.00 | WAB - Willacy fine sandy loam, 1 to 3 percent slopes |
| 6 | 1.0 | 0 - 1 | 0.50 | RR - Rio Grande silt loam |
| | | 1 - 3 | 2.00 | RT - Rio Grande silty clay loam |
| | | 0 - 1 | 0.50 | RZ - Rio Grande-Zalla complex |
| 7 | > 1.0 | 0 - 12 | 6.00 | GA - Galveston fine sand, hummocky |
| (Not Farmed) | non-typical | 0 - 1 | 0.50 | TC - Tiocano clay |
| | > 1.0 | 0 - 1 | 0.50 | ZA - Zalla loamy fine sand |

[1] Basis for soil groupings: Soil intake curve, water holding capacity, and crop suitability.
[2] Lower Rio Grande Plain Irrigation Guide, USDA-NRCS (June 1983).

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 1 (without subsurface drains)

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : HARLINGEN |
| Horizons | : 3 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:36:35 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0412 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : HA |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : D |
| Soil Surface Texture | : C |
| Slope % | : .00 - 1.00 |

| | | | | |
|---|---|---|---|---|
| SALB | .02 | .11 | .18 | |
| Z | .01 | .28 | .89 | 1.80 |
| BD | 1.12 | 1.12 | 1.15 | 1.23 |
| U | .34 | .34 | .42 | .40 |
| FC | .48 | .48 | .50 | .48 |
| SAN | 17.19 | 17.19 | 9.61 | 11.11 |
| SIL | 27.81 | 27.81 | 22.39 | 25.89 |
| PH | 8.15 | 8.15 | 8.15 | 8.15 |
| CBN | 1.16 | 1.16 | .39 | .13 |
| CEC | 49.93 | 49.93 | 56.38 | 51.06 |
| ROK | .00 | .00 | .00 | .00 |
| BDD | 1.71 | 1.71 | 1.90 | 1.90 |
| SC | .20 | .20 | .04 | .06 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 1 (with subsurface drains)

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : MERCEDES |
| Horizons | : 3 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:43:01 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0477 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : MEA |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : D |
| Soil Surface Texture | : C |
| Slope % | : .00- 1.00 |

| | | | | |
|---|---|---|---|---|
| SALB | .02 | .11 | .18 | |
| Z | .01 | .46 | 1.19 | 1.88 |
| BD | 1.18 | 1.18 | 1.32 | 1.37 |
| U | .30 | .30 | .33 | .31 |
| FC | .44 | .44 | .43 | .41 |
| SAN | 22.23 | 22.23 | 18.14 | 22.23 |
| SIL | 27.77 | 27.77 | 29.36 | 27.77 |
| PH | 8.15 | 8.15 | 8.45 | 8.45 |
| CBN | 1.16 | 1.16 | .39 | .13 |
| CEC | 45.93 | 45.93 | 43.98 | 40.66 |
| ROK | 6.27 | 6.27 | 6.38 | 6.68 |
| BDD | 1.68 | 1.68 | 1.83 | 1.84 |
| SC | .38 | .38 | .17 | .23 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 2

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : RAYMONDVILLE |
| Horizons | : 3 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:37:54 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0169 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : RE |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : D |
| Soil Surface Texture | : CL |
| Slope % | : .00- 1.00 |

| | | | | |
|---|---|---|---|---|
| SALB | .02 | .11 | .18 | |
| Z | .01 | .36 | .94 | 1.98 |
| BD | 1.34 | 1.34 | 1.49 | 1.51 |
| U | .23 | .23 | .25 | .25 |
| FC | .41 | .41 | .41 | .39 |
| SAN | 30.44 | 30.44 | 29.23 | 29.23 |
| SIL | 32.56 | 32.56 | 31.27 | 31.27 |
| PH | 8.15 | 8.15 | 8.15 | 8.15 |
| CBN | 1.16 | 1.16 | .39 | .13 |
| CEC | 24.43 | 24.43 | 21.73 | 20.41 |
| ROK | .00 | .00 | 1.29 | 3.97 |
| BDD | 1.57 | 1.57 | 1.72 | 1.74 |
| SC | 2.81 | 2.81 | 1.28 | 1.15 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 2

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : OLMITO |
| Horizons | : 2 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:43:40 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0518 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : OM |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : D |
| Soil Surface Texture | : SIC |
| Slope % | : .00 - 1.00 |

| | | | |
|---|---|---|---|
| SALB | .02 | .11 | |
| Z | .01 | .86 | 1.60 |
| BD | 1.27 | 1.27 | 1.35 |
| U | .32 | .32 | .30 |
| FC | .48 | .48 | .44 |
| SAN | 5.52 | 5.52 | 7.37 |
| SIL | 46.98 | 46.98 | 47.63 |
| PH | 8.15 | 8.15 | 8.15 |
| CBN | 1.16 | 1.16 | .39 |
| CEC | 43.93 | 43.93 | 37.98 |
| ROK | .00 | .00 | 2.89 |
| BDD | 1.70 | 1.70 | 1.75 |
| SC | .15 | .15 | .14 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 3

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : LAREDO |
| Horizons | : 2 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:38:46 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0446 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : LAA |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : B |
| Soil Surface Texture | : SICL |
| Slope % | : .00 - 1.00 |

| | | | |
|---|---|---|---|
| SALB | .02 | .13 | |
| Z | .01 | .46 | 1.83 |
| BD | 1.30 | 1.30 | 1.46 |
| U | .15 | .15 | .18 |
| FC | .37 | .37 | .39 |
| SAN | 7.16 | 7.16 | 6.82 |
| SIL | 65.34 | 65.34 | 61.68 |
| PH | 8.15 | 8.15 | 8.15 |
| CBN | 1.16 | 1.16 | .29 |
| CEC | 10.06 | 10.06 | 6.21 |
| ROK | .00 | .00 | 1.34 |
| BDD | 1.36 | 1.36 | 1.52 |
| SC | 1.36 | 1.36 | .92 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 4

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : HIDALGO |
| Horizons | : 3 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:39:44 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0226 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : HO |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : B |
| Soil Surface Texture | : SCL |
| Slope % | : .00- 1.00 |

| | | | | |
|---|---|---|---|---|
| SALB | .02 | .11 | .18 | |
| Z | .01 | .43 | .71 | 2.03 |
| BD | 1.43 | 1.43 | 1.58 | 1.60 |
| U | .17 | .17 | .19 | .19 |
| FC | .31 | .31 | .31 | .31 |
| SAN | 56.98 | 56.98 | 55.46 | 53.94 |
| SIL | 18.02 | 18.02 | 17.54 | 17.06 |
| PH | 8.15 | 8.15 | 8.15 | 8.15 |
| CBN | 1.16 | 1.16 | .39 | .13 |
| CEC | 18.43 | 18.43 | 15.48 | 15.16 |
| ROK | 1.43 | 1.43 | 1.27 | 5.36 |
| BDD | 1.57 | 1.57 | 1.72 | 1.75 |
| SC | 11.76 | 11.76 | 5.93 | 4.57 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point. 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 5

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : WILLACY |
| Horizons | : 2 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:40:38 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0156 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : WAA |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : B |
| Soil Surface Texture | : FSL |
| Slope % | : .00 - 1.00 |

| | | | |
|---|---|---|---|
| SALB | .02 | .11 | |
| Z | .01 | .36 | 1.88 |
| BD | 1.46 | 1.46 | 1.58 |
| U | .11 | .11 | .17 |
| FC | .24 | .24 | .30 |
| SAN | 65.33 | 65.33 | 56.60 |
| SIL | 19.67 | 19.67 | 17.90 |
| PH | 7.20 | 7.20 | 7.50 |
| CBN | 1.16 | 1.16 | .39 |
| CEC | 13.43 | 13.43 | 14.73 |
| ROK | .00 | .00 | 2.89 |
| BDD | 1.54 | 1.54 | 1.71 |
| SC | 36.93 | 36.93 | 6.59 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 6

| | |
|---|---|
| Execution Mode | : EPIC |
| SOIL NAME | : RIO GRANDE |
| Horizons | : 2 |
| Execution Date | : 7-07-1997 |
| Execution Time | : 19:41:32 |

*** INPUTS ***

| | |
|---|---|
| State | : TX |
| S5 Number | : TX0542 |
| Soil Survey Area | : 061 |
| Map Unit Symbol | : RR |
| Map Unit Kind | : Consociation |
| Component Number | : 1 |
| Component Percentage | : 100.00000 |
| Number of Components | : 1 |
| Hydrological Group | : B |
| Soil Surface Texture | : SIL |
| Slope % | : .00 - 1.00 |

| | | | |
|---|---|---|---|
| SALB | .10 | .10 | |
| Z | .01 | .18 | 1.60 |
| BD | 1.43 | 1.43 | 1.52 |
| U | .07 | .07 | .08 |
| FC | .27 | .27 | .28 |
| SAN | 20.98 | 20.98 | 20.75 |
| SIL | 68.02 | 68.02 | 67.25 |
| PH | 8.15 | 8.15 | 8.15 |
| CBN | .44 | .44 | .44 |
| CEC | 3.87 | 3.87 | 4.02 |
| ROK | .00 | .00 | .00 |
| BDD | 1.46 | 1.46 | 1.55 |
| SC | 5.76 | 5.76 | 3.94 |

Definition of soil variables:

| | |
|---|---|
| SALB | Soil albedo |
| Z | Depth from the surface to the bottom of the soil layer (m) |
| BD | Bulk density of the soil layer (t/m3) |
| U | Wilting point, 1500 kPa (m/m) |
| FC | Field capacity, 33 kPa (m/m) |
| SAN | Sand content (%) |
| SIL | Silt content (%) |
| PH | Soil pH |
| CBN | Organic carbon(%) |
| CEC | Cation exchange capacity (cmo/kg) |
| ROK | Coarse fragment content (% vol) |
| BDD | Bulk density, oven dry (t/m3) |
| SC | Saturated conductivity (mm/hr) |

## MUIR Soil Data for Cameron County

| State | Survey Area | Map Unit | Soil Group | Series Name | ID # | $Slope_{min}$ | $Slope_{max}$ | Average Slope | Surface Texture | Acreage | Average Depth to Water Table | Hydrologic Soil Group | Natural Drainage Condition | Hydric Soil | Non-irrigated Capability Class | Irrigated Capability Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TX | 61 | BE | 1 | BENITO | TX0236 | 0 | 1 | 0.5 | C | 25730 | 154380 | D | P | Y | 6S | 4W |
| TX | 61 | GR | 1 | GRULLA | TX0396 | 0 | 1 | 0.5 | C | 1530 | 9180 | D | SP | Y | 4W | 4W |
| TX | 61 | HA | 1 | HARLINGEN | TX0412 | 0 | 1 | 0.5 | C | 49730 | 298380 | D | MW | N | 3S | 3S |
| TX | 61 | HC | 1 | HARLINGEN | TX0413 | 0 | 1 | 0.5 | C | 4110 | 24660 | D | MW | N | 4S | 4S |
| TX | 61 | MEA | 1 | MERCEDES | TX0477 | 0 | 1 | 0.5 | C | 16950 | 101700 | D | MW | N | 3S | 3S |
| TX | 61 | MEB | 1 | MERCEDES | TX0477 | 1 | 3 | 2.0 | C | 1780 | 10680 | D | MW | N | 3E | 3E |
| TX | 61 | MGC | 1 | MERCEDES | TX0780 | 1 | 5 | 3.0 | C | 2240 | 13440 | D | MW | N | 4E | 4E |
| TX | 61 | OR | 1 | ORELIA VARIANT | TX0781 | 0 | 1 | 0.5 | CL | 1100 | 6600 | D | SP | Y | 4S | 4S |
| | | | | | | | | **0.58** | | **103170** | **6.00** | | | | | |
| TX | 61 | CE | 2 | CAMERON | TX0232 | 0 | 1 | 0.5 | SIC | 1840 | 10120 | D | MW | N | 2S | 2S |
| TX | 61 | MA | 2 | MATAMOROS | TX0379 | 0 | 1 | 0.5 | SIC | 6090 | 36540 | C | MW | N | 2S | 2S |
| TX | 61 | MC | 2 | MATAMOROS | TX0379 | 0 | 1 | 0.5 | SIL | 864 | 5184 | C | MW | N | 2S | 2S |
| TX | 61 | MC | 2 | RIO GRANDE | TX0542 | 0 | 1 | 0.5 | SIL | 766 | 4596 | B | W | N | 3C | 1 |
| TX | 61 | OM | 2 | OLMITO | TX0518 | 0 | 1 | 0.5 | SIC | 29940 | 179640 | D | MW | N | 2S | 2S |
| TX | 61 | RE | 2 | RAYMONDVILLE | TX0169 | 0 | 1 | 0.5 | CL | 49540 | 297240 | D | MW | N | 2S | 2S |
| TX | 61 | RG | 2 | RAYMONDVILLE | TX0170 | 0 | 1 | 0.5 | CL | 700 | 2450 | D | MW | N | 4S | 4S |
| TX | 61 | RO | 2 | RIO | TX0043 | 0 | 1 | 0.5 | CL | 1240 | 7440 | D | SP | Y | 3W | 3W |
| | | | | | | | | **0.50** | | **90980** | **5.97** | | | | | |
| TX | 61 | CA | 3 | CAMERGO | TX0281 | 0 | 1 | 0.5 | SIL | 2240 | 13440 | B | W | N | 3C | 1 |
| TX | 61 | CC | 3 | CAMARGO | TX0281 | 0 | 1 | 0.5 | SICL | 600 | 3600 | B | W | N | 3C | 1 |
| TX | 61 | LAA | 3 | LAREDO | TX0446 | 0 | 1 | 0.5 | SICL | 64420 | 386520 | B | W | N | 2C | 1 |
| TX | 61 | LAB | 3 | LAREDO | TX0446 | 1 | 3 | 2.0 | SICL | 2470 | 14820 | B | W | N | 2E | 2E |
| TX | 61 | LC | 3 | LAREDO | TX0447 | 0 | 1 | 0.5 | SICL | 12410 | 46537.5 | B | MW | N | 4S | 3S |
| TX | 61 | LD | 3 | LAREDO | TX0446 | 0 | 1 | 0.5 | SICL | 2982 | 17892 | B | W | N | 2C | 1 |
| TX | 61 | LD | 3 | OLMITO | TX0518 | 0 | 1 | 0.5 | SIC | 1828 | 10968 | D | MW | N | 2S | 2S |
| TX | 61 | LEA | 3 | LAREDO | TX0446 | 0 | 1 | 0.5 | SICL | 1862 | 11172 | B | W | N | 2C | 1 |
| TX | 61 | LEA | 3 | REYNOSA | TX0541 | 0 | 1 | 0.5 | SIL | 1348 | 8088 | B | W | N | 3C | 1 |
| TX | 61 | LEB | 3 | LAREDO | TX0446 | 1 | 3 | 2.0 | SICL | 253 | 1518 | B | W | N | 2E | 2E |
| TX | 61 | LEB | 3 | REYNOSA | TX0541 | 1 | 3 | 2.0 | SIL | 207 | 1242 | B | W | N | 3C | 1 |
| | | | | | | | | **0.55** | | **90620** | **5.69** | | | | | |
| TX | 61 | HGA | 4 | HIDALGO | TX0226 | 0 | 1 | 0.5 | FSL | 1330 | 7980 | B | W | N | 2C | 1 |
| TX | 61 | HGB | 4 | HIDALGO | TX0226 | 1 | 3 | 2.0 | FSL | 570 | 3420 | B | W | N | 2E | 2E |
| TX | 61 | HO | 4 | HIDALGO | TX0226 | 0.2 | 0.3 | 0.25 | SCL | 22100 | 132600 | B | W | N | 2C | 1 |
| TX | 61 | LY | 4 | LYFORD | TX0473 | 0.3 | 0.5 | 0.4 | SCL | 10950 | 43800 | C | MW | N | 2W | 2W |
| TX | 61 | RA | 4 | RACOMBES | TX0105 | 0.1 | 0.2 | 0.15 | SCL | 19610 | 93147.5 | B | MW | N | 2W | 2W |
| | | | | | | | | **0.27** | | **54560** | **5.15** | | | | | |
| TX | 61 | WAA | 5 | WILLACY | TX0156 | 0 | 1 | 0.5 | FSL | 28570 | 171420 | B | W | N | 2C | 1 |
| TX | 61 | WAB | 5 | WILLACY | TX0156 | 1 | 3 | 2.0 | FSL | 3200 | 19200 | B | W | N | 2E | 2E |
| | | | | | | | | **0.65** | | **31770** | **6.00** | | | | | |
| TX | 61 | RR | 6 | RIO GRANDE | TX0542 | 0 | 1 | 0.5 | SIL | 9440 | 56640 | B | W | N | 3C | 1 |
| TX | 61 | RT | 6 | RIO GRANDE | TX0542 | 1 | 3 | 2.0 | SICL | 1580 | 9480 | B | W | N | 3E | 2E |
| TX | 61 | RZ | 6 | RIO GRANDE | TX0542 | 0 | 1 | 0.5 | VFSL | 253 | 1518 | B | W | N | 3C | 1 |
| TX | 61 | RZ | 6 | ZALLA | TX0580 | 0 | 1 | 0.5 | LFS | 207 | 1242 | A | SE | N | 4W | 4W |
| | | | | | | | | **0.71** | | **11480** | **6.00** | | | | | |
| TX | 61 | GA | 7 | GALVESTON | TX0221 | 0 | 12 | 6.0 | FS | 2730 | 12285 | A | SE | N | 7E | |
| TX | 61 | TC | 7 | TIOCANO | TX0564 | 0 | 1 | 0.5 | C | 3630 | 21780 | D | SP | Y | 6W | |
| TX | 61 | ZA | 7 | ZALLA | TX0580 | 0 | 1 | 0.5 | LFS | 1650 | 9900 | A | SE | N | 4W | 4W |
| | | | | | | | | **2.37** | | **8010** | **5.49** | | | | | |

**Data Description:**

***Survey Area*** - A three-digit number which uniquely identifies a survey area and is usually the county FIPS code.

***Map Unit*** - The symbol used on the soil map to identify the soil type.

***Soil Group*** - The soil grouping determined for this project based on soil intake curve, water holding capacity, and crop suitability.

***Series Name*** - The name of the soil series or component of a soil complex.

***ID Number*** - The Soil Interpretations Record (SOI-5) identification number.

***Slope min*** - The minimum value for the range of slope of a soil component. Units = percent

***Slope max*** - The maximum value for the range of slope of a soil component. Units = percent

***Average Slope*** - Calculated from minimum and maximum slopes for the map unit. $(Slope_{min} + Slope_{max})/2$ Units = percent

***Surface Texture*** - Code for the USDA texture for the surface layer or horizon.

C - Clay
CL - Clay loam
SIC - Silty clay
SIL - Silty loam
SICL - Silty clay loam
FSL - Fine sandy loam
SCL - Sandy clay loam
VFSL - Very fine sandy loam
LFS - Loamy fine sand
FS - Fine sand

***Acreage*** - Acreage of the soil component of the map unit in Cameron County. Units = acres

***Average Depth to Water Table*** - Calculated from the minimum and maximum value for the range in depth to the seasonally high water table $(Depth_{min} + Depth_{max})/2$. Units = feet

***Hydrologic Soil Group*** - The hydrologic soil group for the soil.

***Natural Drainage Condition Code*** - Code describing the natural drainage condition of the soil referring to the frequency and duration of periods when the soil is free of saturation.

| | |
|---|---|
| P | poorly drained |
| SP | somewhat poorly drained |
| MW | moderately well drained |
| W | well drained |
| SE | somewhat excessively drained |

***Hydric Soil*** - The symbol Y (yes) or N (no) identifying hydric soils.

***Non-Irrigated Capability Class and Subclass Rating*** - A rating of the soil for non-irrigated agricultural use. The number indicates progressively greater limitations and narrower choices for use.

***Irrigated Capability Class and Subclass Rating*** - A rating of the soil for irrigated agricultural use. The number indicates progressively greater limitations and narrower choices for use.

A detailed description of capability classes is available in the Cameron County Soil Survey (USDA-SCS, 1977).

# APPENDIX B

## Land Use in the Arroyo Colorado Study Area

| Cropping System | Soil Group | Dominant Soil/ Representative of Soil Grouping | Hydrologic Soil Group | Runoff Curve # | Subsurface Drainage | Irrigation Land Leveling (Precision Land Forming) | Acreage (Ac) | Acreage (Ha) |
|---|---|---|---|---|---|---|---|---|
| Irrigated Cotton-Grain Sorghum | | | (85% of cotton rotated with Grain Sorghum) | | | | **44,599** | **18,049** |
| | 1 | Mercedes Clay (MEA) | D | 89 | No | 80% | 11,945 | 4,834 |
| | 1 | Mercedes Clay (MEA) | D | 89 | Yes | 80% | 10,434 | 4,223 |
| | 2 | Raymondville Clay Loam (RE) | D | 89 | Yes | 80% | 7,766 | 3,143 |
| | 3 | Laredo Silty Clay Loam (LAA) | B | 78 | Yes | 80% | 3,078 | 1,246 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 78 | Yes | 80% | 8,656 | 3,503 |
| | 5 | Willacy Fine Sandy Loam (WAA) | B | 78 | Yes | 80% | 2,128 | 861 |
| | 6 | Rio Grande Silt Loam (RR) | B | 78 | Yes | 80% | 592 | 239 |
| Irrigated Cotton-Corn | | | (15% of cotton rotated with Corn) | | | | **7,870** | **3,185** |
| | 1 | Harlingen Clay (HA) | D | 89 | No | 80% | 2,108 | 853 |
| | 1 | Mercedes Clay (MEA) | D | 89 | Yes | 80% | 1,841 | 745 |
| | 2 | Raymondville Clay Loam (RE) | D | 89 | Yes | 80% | 1,370 | 555 |
| | 3 | Laredo Silty Clay Loam (LAA) | B | 78 | Yes | 80% | 543 | 220 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 78 | Yes | 80% | 1,528 | 618 |
| | 5 | Willacy Fine Sandy Loam (WAA) | B | 78 | Yes | 80% | 376 | 152 |
| | 6 | Rio Grande Silt Loam (RR) | B | 78 | Yes | 80% | 104 | 42 |
| Dryland Cotton-Grain Sorghum | | | (85% of cotton rotated with Grain Sorghum) | | | | **628** | **254** |
| | 1 | Mercedes Clay (MEA) | D | 89 | No | 80% | 598 | 242 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 78 | No | 80% | 30 | 12 |
| Dryland Cotton-Corn | | | (15% of cotton rotated with Corn) | | | | **111** | **45** |
| | 1 | Mercedes Clay (MEA) | D | 89 | No | 80% | 106 | 43 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 78 | No | 80% | 5 | 2 |
| Irrigated Sugar Cane | | | | | | | **7,658** | **3,099** |
| | 1 | Harlingen Clay (HA) | D | 82 | No | 80% | 1,407 | 569 |
| | 1 | Mercedes Clay (MEA) | D | 82 | Yes | 80% | 419 | 170 |
| | 2 | Olmito Silty Clay (OM) | D | 82 | Yes | 80% | 1,909 | 773 |
| | 3 | Laredo Silty Clay Loam (LAA) | B | 65 | Yes | 80% | 3,304 | 1,337 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 65 | Yes | 80% | 524 | 212 |
| | 5 | Willacy Fine Sandy Loam (WAA) | B | 65 | Yes | 80% | 28 | 11 |
| | 6 | Rio Grande Silt Loam (RR) | B | 65 | Yes | 80% | 67 | 27 |
| Irrigated Citrus | | | | | | | **1,984** | **803** |
| | 1 | Mercedes Clay (MEA) | D | 83 | No | 100% | 14 | 6 |
| | 2 | Raymondville Clay Loam (RE) | D | 83 | No | 100% | 158 | 64 |
| | 3 | Laredo Silty Clay Loam (LAA) | B | 66 | No | 100% | 45 | 18 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | B | 66 | No | 100% | 1,357 | 549 |
| | 5 | Willacy Fine Sandy Loam (WAA) | B | 66 | No | 100% | 410 | 166 |
| Non-Row Crop Agriculture/Perennial Vegetation | | | | | | | **17,566** | **7,109** |
| | 1 | Harlingen Clay (HA) | | | | | 5,368 | 2,172 |
| | 2 | Raymondville Clay Loam (RE) | | | | | 3,959 | 1,602 |
| | 3 | Laredo Silty Clay Loam (LAA) | | | | | 1,984 | 803 |
| | 4 | Hidalgo Sandy Clay Loam (HO) | | | | | 3,051 | 1,235 |
| | 5 | Willacy Fine Sandy Loam (WAA) | | | | | 258 | 104 |
| | 6 | Rio Grande Silt Loam (RR) | | | | | 949 | 384 |
| | 7 | Tiocano Clay (TC) - *not typically farmed* | | | | | 1,997 | 808 |
| Non-Agricultural Areas | | | | | | | **9,700** | **3,926** |
| Water/Pits | | | | | | | 3,462 | 1,401 |
| Urban Areas | | | | | | | 6,238 | 2,525 |
| **TOTAL** | | | | | | | **90,116** | **36,470** |

# APPENDIX C

## Monthly Climatic Summaries for Harlingen

### Monthly Temperature Data for Harlingen

| YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1954 | 1 | 1 | 31 | 1955 | 1 | 0 | 30 | 1956 | 1 | 1 | 30 | 1957 | 1 | 0 | 32 |
| | 2 | 3 | 36 | | 2 | -2 | 31 | | 2 | 1 | 32 | | 2 | 8 | 34 |
| | 3 | 3 | 39 | | 3 | 3 | 34 | | 3 | 3 | 37 | | 3 | 6 | 33 |
| | 4 | 12 | 37 | | 4 | 13 | 41 | | 4 | 13 | 36 | | 4 | 11 | 35 |
| | 5 | 10 | 38 | | 5 | 18 | 38 | | 5 | 14 | 36 | | 5 | 15 | 37 |
| | 6 | 20 | 37 | | 6 | 19 | 38 | | 6 | 19 | 41 | | 6 | 19 | 37 |
| | 7 | 21 | 42 | | 7 | 21 | 37 | | 7 | 21 | 39 | | 7 | 22 | 40 |
| | 8 | 21 | 40 | | 8 | 20 | 38 | | 8 | 19 | 41 | | 8 | 21 | 39 |
| | 9 | 18 | 37 | | 9 | 20 | 34 | | 9 | 17 | 38 | | 9 | 16 | 39 |
| | 10 | 9 | 35 | | 10 | 9 | 34 | | 10 | 12 | 37 | | 10 | 7 | 36 |
| | 11 | 4 | 31 | | 11 | 5 | 32 | | 11 | 1 | 34 | | 11 | 2 | 32 |
| | 12 | 2 | 31 | | 12 | 2 | 31 | | 12 | 4 | 31 | | 12 | -2 | 28 |
| 1958 | 1 | 2 | 27 | 1959 | 1 | -1 | 28 | 1960 | 1 | 1 | 31 | 1961 | 1 | 1 | 27 |
| | 2 | 1 | 31 | | 2 | 3 | 32 | | 2 | -1 | 32 | | 2 | 1 | 30 |
| | 3 | 4 | 32 | | 3 | 4 | 32 | | 3 | 2 | 32 | | 3 | 9 | 36 |
| | 4 | 11 | 37 | | 4 | 11 | 35 | | 4 | 7 | 33 | | 4 | 7 | 37 |
| | 5 | 16 | 35 | | 5 | 18 | 37 | | 5 | 11 | 37 | | 5 | 12 | 36 |
| | 6 | 21 | 38 | | 6 | 19 | 36 | | 6 | 20 | 38 | | 6 | 20 | 37 |
| | 7 | 22 | 38 | | 7 | 21 | 39 | | 7 | 23 | 40 | | 7 | 21 | 38 |
| | 8 | 17 | 40 | | 8 | 23 | 40 | | 8 | 22 | 39 | | 8 | 19 | 38 |
| | 9 | 20 | 38 | | 9 | 17 | 39 | | 9 | 14 | 35 | | 9 | 17 | 38 |
| | 10 | 10 | 34 | | 10 | 10 | 37 | | 10 | 11 | 36 | | 10 | 9 | 34 |
| | 11 | 4 | 31 | | 11 | 0 | 33 | | 11 | 6 | 31 | | 11 | 7 | 33 |
| | 12 | -2 | 28 | | 12 | 2 | 28 | | 12 | 2 | 28 | | 12 | 2 | 31 |
| 1962 | 1 | -10 | 29 | 1963 | 1 | -6 | 32 | 1964 | 1 | -2 | 28 | 1965 | 1 | 1 | 31 |
| | 2 | 3 | 35 | | 2 | -1 | 37 | | 2 | 2 | 27 | | 2 | 0 | 30 |
| | 3 | 1 | 31 | | 3 | 3 | 33 | | 3 | 4 | 35 | | 3 | 1 | 31 |
| | 4 | 4 | 36 | | 4 | 14 | 38 | | 4 | 10 | 38 | | 4 | 12 | 37 |
| | 5 | 16 | 35 | | 5 | 17 | 34 | | 5 | 16 | 37 | | 5 | 13 | 34 |
| | 6 | 21 | 38 | | 6 | 20 | 38 | | 6 | 16 | 36 | | 6 | 20 | 37 |
| | 7 | 20 | 38 | | 7 | 16 | 37 | | 7 | 22 | 38 | | 7 | 20 | 38 |
| | 8 | 21 | 41 | | 8 | 21 | 39 | | 8 | 22 | 38 | | 8 | 20 | 37 |
| | 9 | 16 | 37 | | 9 | 16 | 36 | | 9 | 18 | 37 | | 9 | 17 | 38 |
| | 10 | 10 | 37 | | 10 | 14 | 32 | | 10 | 7 | 34 | | 10 | 8 | 32 |
| | 11 | 5 | 32 | | 11 | 3 | 32 | | 11 | 5 | 33 | | 11 | 9 | 34 |
| | 12 | 2 | 29 | | 12 | -3 | 26 | | 12 | -1 | 32 | | 12 | 4 | 27 |

| YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) | YEAR | MO. | MIN T (C) | MAX T (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1966** | 1 | -1 | 27 | **1967** | 1 | -2 | 29 | **1968** | 1 | -1 | 27 | **1969** | 1 | -2 | 31 |
| | 2 | 0 | 27 | | 2 | -1 | 30 | | 2 | -1 | 29 | | 2 | 6 | 30 |
| | 3 | 0 | 33 | | 3 | 6 | 33 | | 3 | 1 | 30 | | 3 | 3 | 33 |
| | 4 | 9 | 34 | | 4 | 14 | 35 | | 4 | 8 | 33 | | 4 | 12 | 35 |
| | 5 | 16 | 34 | | 5 | 14 | 37 | | 5 | 14 | 34 | | 5 | 15 | 35 |
| | 6 | 14 | 36 | | 6 | 17 | 38 | | 6 | 19 | 36 | | 6 | 16 | 38 |
| | 7 | 18 | 36 | | 7 | 19 | 37 | | 7 | 21 | 37 | | 7 | 21 | 38 |
| | 8 | 21 | 38 | | 8 | 16 | 38 | | 8 | 21 | 38 | | 8 | 21 | 39 |
| | 9 | 16 | 38 | | 9 | 12 | 34 | | 9 | 15 | 36 | | 9 | 17 | 36 |
| | 10 | 9 | 36 | | 10 | 9 | 32 | | 10 | 10 | 36 | | 10 | 11 | 34 |
| | 11 | 1 | 32 | | 11 | 6 | 31 | | 11 | 3 | 33 | | 11 | -2 | 34 |
| | 12 | -3 | 29 | | 12 | 1 | 30 | | 12 | 1 | 33 | | 12 | 3 | 28 |
| **1970** | 1 | -3 | 27 | **1971** | 1 | -1 | 34 | **1972** | 1 | 1 | 32 | **1973** | 1 | -4 | 27 |
| | 2 | 1 | 27 | | 2 | -1 | 33 | | 2 | 1 | 31 | | 2 | -3 | 30 |
| | 3 | 2 | 33 | | 3 | 1 | 38 | | 3 | 6 | 38 | | 3 | 7 | 32 |
| | 4 | 7 | 35 | | 4 | 6 | 35 | | 4 | 8 | 36 | | 4 | 6 | 36 |
| | 5 | 9 | 33 | | 5 | 13 | 36 | | 5 | 16 | 33 | | 5 | 14 | 40 |
| | 6 | 14 | 35 | | 6 | 20 | 34 | | 6 | 19 | 36 | | 6 | 18 | 36 |
| | 7 | 20 | 36 | | 7 | 21 | 36 | | 7 | 20 | 35 | | 7 | 21 | 37 |
| | 8 | 18 | 38 | | 8 | 20 | 37 | | 8 | 21 | 37 | | 8 | 21 | 38 |
| | 9 | 14 | 38 | | 9 | 16 | 38 | | 9 | 21 | 37 | | 9 | 18 | 36 |
| | 10 | 7 | 34 | | 10 | 13 | 33 | | 10 | 11 | 34 | | 10 | 14 | 34 |
| | 11 | -1 | 31 | | 11 | 8 | 32 | | 11 | 4 | 34 | | 11 | 0 | 0 |
| | 12 | 6 | 31 | | 12 | 4 | 29 | | 12 | 1 | 32 | | 12 | -4 | 30 |
| **1974** | 1 | 1 | 29 | **1975** | 1 | -4 | 29 | **1976** | 1 | -2 | 28 | **1977** | 1 | -2 | 27 |
| | 2 | 0 | 30 | | 2 | 2 | 31 | | 2 | 1 | 29 | | 2 | 2 | 28 |
| | 3 | 6 | 37 | | 3 | 7 | 34 | | 3 | 6 | 32 | | 3 | 4 | 31 |
| | 4 | 7 | 37 | | 4 | 9 | 34 | | 4 | 9 | 30 | | 4 | 8 | 34 |
| | 5 | 19 | 41 | | 5 | 17 | 34 | | 5 | 8 | 32 | | 5 | 18 | 35 |
| | 6 | 15 | 37 | | 6 | 14 | 34 | | 6 | 17 | 35 | | 6 | 19 | 35 |
| | 7 | 21 | 37 | | 7 | 21 | 34 | | 7 | 20 | 33 | | 7 | 20 | 37 |
| | 8 | 21 | 38 | | 8 | 21 | 35 | | 8 | 19 | 35 | | 8 | 21 | 37 |
| | 9 | 15 | 37 | | 9 | 12 | 33 | | 9 | 18 | 36 | | 9 | 19 | 38 |
| | 10 | 9 | 32 | | 10 | 11 | 32 | | 10 | 7 | 32 | | 10 | 9 | 36 |
| | 11 | 2 | 30 | | 11 | 3 | 31 | | 11 | -1 | 28 | | 11 | 6 | 33 |
| | 12 | 3 | 29 | | 12 | 2 | 28 | | 12 | 1 | 27 | | 12 | 0 | 33 |

## Monthly Rainfall Data for Harlingen

| YEAR | MO. | Monthly Rain (mm) | Monthly Rain (in.) | YEAR | MO. | Monthly Rain (mm) | Monthly Rain (in.) | YEAR | MO. | Monthly Rain (mm) | Monthly Rain (in.) | YEAR | MO. | Monthly Rain (mm) | Monthly Rain (in.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1954** | 1 | 8.1 | 0.32 | **1955** | 1 | 19.1 | 0.75 | **1956** | 1 | 0.3 | 0.01 | **1957** | 1 | 4.4 | 0.17 |
| | 2 | 0.3 | 0.01 | | 2 | 7.1 | 0.28 | | 2 | 29.7 | 1.17 | | 2 | 61.6 | 2.43 |
| | 3 | 9.7 | 0.38 | | 3 | 0.8 | 0.03 | | 3 | 5.9 | 0.23 | | 3 | 66.5 | 2.62 |
| | 4 | 106.2 | 4.18 | | 4 | 9.1 | 0.36 | | 4 | 61.9 | 2.44 | | 4 | 110.3 | 4.34 |
| | 5 | 11.9 | 0.47 | | 5 | 24.6 | 0.97 | | 5 | 6.6 | 0.26 | | 5 | 59.0 | 2.32 |
| | 6 | 61.7 | 2.43 | | 6 | 0.0 | 0.00 | | 6 | 50.3 | 1.98 | | 6 | 169.5 | 6.67 |
| | 7 | 4.6 | 0.18 | | 7 | 144.9 | 5.70 | | 7 | 16.3 | 0.64 | | 7 | 1.8 | 0.07 |
| | 8 | 86.7 | 3.41 | | 8 | 51.1 | 2.01 | | 8 | 7.6 | 0.30 | | 8 | 8.6 | 0.34 |
| | 9 | 30.8 | 1.21 | | 9 | 312.6 | 12.31 | | 9 | 42.3 | 1.67 | | 9 | 11.1 | 0.44 |
| | 10 | 172.1 | 6.78 | | 10 | 68.7 | 2.70 | | 10 | 39.4 | 1.55 | | 10 | 7.8 | 0.31 |
| | 11 | 35.1 | 1.38 | | 11 | 47.0 | 1.85 | | 11 | 8.2 | 0.32 | | 11 | 75.1 | 2.96 |
| | 12 | 2.3 | 0.09 | | 12 | 6.4 | 0.25 | | 12 | 1.8 | 0.07 | | 12 | 8.5 | 0.33 |
| **1958** | 1 | 130.1 | 5.12 | **1959** | 1 | 39.1 | 1.54 | **1960** | 1 | 5.6 | 0.22 | **1961** | 1 | 35.2 | 1.39 |
| | 2 | 181.1 | 7.13 | | 2 | 60.8 | 2.39 | | 2 | 25.6 | 1.01 | | 2 | 6.5 | 0.26 |
| | 3 | 18.9 | 0.74 | | 3 | 8.1 | 0.32 | | 3 | 27.2 | 1.07 | | 3 | 0.0 | 0.00 |
| | 4 | 2.1 | 0.08 | | 4 | 44.8 | 1.76 | | 4 | 58.0 | 2.28 | | 4 | 63.3 | 2.49 |
| | 5 | 64.2 | 2.53 | | 5 | 136.6 | 5.38 | | 5 | 34.0 | 1.34 | | 5 | 10.7 | 0.42 |
| | 6 | 59.5 | 2.34 | | 6 | 113.3 | 4.46 | | 6 | 44.7 | 1.76 | | 6 | 45.6 | 1.80 |
| | 7 | 36.9 | 1.45 | | 7 | 16.3 | 0.64 | | 7 | 10.6 | 0.42 | | 7 | 68.3 | 2.69 |
| | 8 | 0.0 | 0.00 | | 8 | 29.1 | 1.15 | | 8 | 159.4 | 6.28 | | 8 | 115.0 | 4.53 |
| | 9 | 204.5 | 8.05 | | 9 | 2.3 | 0.09 | | 9 | 189.1 | 7.44 | | 9 | 210.9 | 8.30 |
| | 10 | 272.8 | 10.74 | | 10 | 135.4 | 5.33 | | 10 | 91.0 | 3.58 | | 10 | 22.9 | 0.90 |
| | 11 | 44.0 | 1.73 | | 11 | 69.4 | 2.73 | | 11 | 29.0 | 1.14 | | 11 | 40.9 | 1.61 |
| | 12 | 42.2 | 1.66 | | 12 | 8.6 | 0.34 | | 12 | 72.1 | 2.84 | | 12 | 18.0 | 0.71 |
| **1962** | 1 | 8.6 | 0.34 | **1963** | 1 | 5.0 | 0.20 | **1964** | 1 | 4.4 | 0.17 | **1965** | 1 | 8.2 | 0.32 |
| | 2 | 3.3 | 0.13 | | 2 | 11.2 | 0.44 | | 2 | 38.4 | 1.51 | | 2 | 68.5 | 2.70 |
| | 3 | 33.0 | 1.30 | | 3 | 1.3 | 0.05 | | 3 | 2.1 | 0.08 | | 3 | 17.2 | 0.68 |
| | 4 | 21.6 | 0.85 | | 4 | 9.9 | 0.39 | | 4 | 19.1 | 0.75 | | 4 | 7.9 | 0.31 |
| | 5 | 17.6 | 0.69 | | 5 | 154.2 | 6.07 | | 5 | 67.2 | 2.65 | | 5 | 28.2 | 1.11 |
| | 6 | 75.7 | 2.98 | | 6 | 47.7 | 1.88 | | 6 | 75.2 | 2.96 | | 6 | 23.6 | 0.93 |
| | 7 | 0.0 | 0.00 | | 7 | 48.7 | 1.92 | | 7 | 10.7 | 0.42 | | 7 | 5.1 | 0.20 |
| | 8 | 22.4 | 0.88 | | 8 | 69.9 | 2.75 | | 8 | 6.9 | 0.27 | | 8 | 70.7 | 2.78 |
| | 9 | 58.0 | 2.28 | | 9 | 109.0 | 4.29 | | 9 | 70.2 | 2.76 | | 9 | 73.6 | 2.90 |
| | 10 | 34.3 | 1.35 | | 10 | 95.3 | 3.75 | | 10 | 12.2 | 0.48 | | 10 | 29.5 | 1.16 |
| | 11 | 49.5 | 1.95 | | 11 | 109.6 | 4.31 | | 11 | 16.5 | 0.65 | | 11 | 95.6 | 3.76 |
| | 12 | 41.7 | 1.64 | | 12 | 64.8 | 2.55 | | 12 | 42.8 | 1.69 | | 12 | 108.3 | 4.26 |

| | | Monthly Rain | | | | Monthly Rain | | | | Monthly Rain | | | | Monthly Rain | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | **MO.** | **(mm)** | **(in.)** | **YEAR** | **MO.** | **(mm)** | **(in.)** | **YEAR** | **MO.** | **(mm)** | **(in.)** | **YEAR** | **MO.** | **(mm)** | **(in.)** |
| **1966** | 1 | 89.6 | 3.53 | **1967** | 1 | 36.3 | 1.43 | **1968** | 1 | 94.0 | 3.70 | **1969** | 1 | 9.9 | 0.39 |
| | 2 | 23.6 | 0.93 | | 2 | 26.2 | 1.03 | | 2 | 39.8 | 1.57 | | 2 | 53.1 | 2.09 |
| | 3 | 20.4 | 0.80 | | 3 | 28.6 | 1.13 | | 3 | 24.1 | 0.95 | | 3 | 21.3 | 0.84 |
| | 4 | 89.3 | 3.52 | | 4 | 2.0 | 0.08 | | 4 | 19.6 | 0.77 | | 4 | 3.3 | 0.13 |
| | 5 | 203.1 | 8.00 | | 5 | 47.7 | 1.88 | | 5 | 122.7 | 4.83 | | 5 | 103.1 | 4.06 |
| | 6 | 130.9 | 5.15 | | 6 | 21.9 | 0.86 | | 6 | 63.3 | 2.49 | | 6 | 15.8 | 0.62 |
| | 7 | 37.6 | 1.48 | | 7 | 14.2 | 0.56 | | 7 | 69.7 | 2.74 | | 7 | 4.8 | 0.19 |
| | 8 | 76.2 | 3.00 | | 8 | 143.6 | 5.65 | | 8 | 68.9 | 2.71 | | 8 | 94.8 | 3.73 |
| | 9 | 65.0 | 2.56 | | 9 | 364.8 | 14.36 | | 9 | 177.3 | 6.98 | | 9 | 148.4 | 5.84 |
| | 10 | 106.4 | 4.19 | | 10 | 133.1 | 5.24 | | 10 | 47.6 | 1.87 | | 10 | 11.2 | 0.44 |
| | 11 | 2.3 | 0.09 | | 11 | 85.3 | 3.36 | | 11 | 12.5 | 0.49 | | 11 | 46.8 | 1.84 |
| | 12 | 8.9 | 0.35 | | 12 | 92.7 | 3.65 | | 12 | 24.1 | 0.95 | | 12 | 7.9 | 0.31 |
| **1970** | 1 | 97.1 | 3.82 | **1971** | 1 | 2.8 | 0.11 | **1972** | 1 | 10.1 | 0.40 | **1973** | 1 | 115.8 | 4.56 |
| | 2 | 22.1 | 0.87 | | 2 | 30.8 | 1.21 | | 2 | 23.4 | 0.92 | | 2 | 185.0 | 7.28 |
| | 3 | 18.3 | 0.72 | | 3 | 0.3 | 0.01 | | 3 | 80.5 | 3.17 | | 3 | 7.9 | 0.31 |
| | 4 | 40.7 | 1.60 | | 4 | 23.6 | 0.93 | | 4 | 26.4 | 1.04 | | 4 | 18.1 | 0.71 |
| | 5 | 111.7 | 4.40 | | 5 | 9.9 | 0.39 | | 5 | 66.4 | 2.61 | | 5 | 11.4 | 0.45 |
| | 6 | 97.8 | 3.85 | | 6 | 59.2 | 2.33 | | 6 | 120.2 | 4.73 | | 6 | 191.1 | 7.52 |
| | 7 | 49.8 | 1.96 | | 7 | 49.8 | 1.96 | | 7 | 72.3 | 2.85 | | 7 | 41.8 | 1.65 |
| | 8 | 33.6 | 1.32 | | 8 | 65.1 | 2.56 | | 8 | 14.7 | 0.58 | | 8 | 227.6 | 8.96 |
| | 9 | 199.2 | 7.84 | | 9 | 303.7 | 11.96 | | 9 | 114.1 | 4.49 | | 9 | 122.7 | 4.83 |
| | 10 | 141.2 | 5.56 | | 10 | 29.1 | 1.15 | | 10 | 13.0 | 0.51 | | 10 | 111.8 | 4.40 |
| | 11 | 8.1 | 0.32 | | 11 | 6.1 | 0.24 | | 11 | 32.3 | 1.27 | | 11 | 42.7 | 1.68 |
| | 12 | 7.8 | 0.31 | | 12 | 35.3 | 1.39 | | 12 | 9.3 | 0.37 | | 12 | 4.4 | 0.17 |
| **1974** | 1 | 30.7 | 1.21 | **1975** | 1 | 39.5 | 1.56 | **1976** | 1 | 15.6 | 0.61 | **1977** | 1 | 45.3 | 1.78 |
| | 2 | 0.5 | 0.02 | | 2 | 14.7 | 0.58 | | 2 | 0.0 | 0.00 | | 2 | 41.8 | 1.65 |
| | 3 | 6.1 | 0.24 | | 3 | 3.1 | 0.12 | | 3 | 20.6 | 0.81 | | 3 | 4.5 | 0.18 |
| | 4 | 25.9 | 1.02 | | 4 | 0.0 | 0.00 | | 4 | 263.7 | 10.38 | | 4 | 85.2 | 3.35 |
| | 5 | 27.9 | 1.10 | | 5 | 50.3 | 1.98 | | 5 | 53.9 | 2.12 | | 5 | 31.5 | 1.24 |
| | 6 | 48.8 | 1.92 | | 6 | 57.7 | 2.27 | | 6 | 94.6 | 3.72 | | 6 | 184.7 | 7.27 |
| | 7 | 31.6 | 1.24 | | 7 | 219.6 | 8.65 | | 7 | 178.6 | 7.03 | | 7 | 47.8 | 1.88 |
| | 8 | 106.9 | 4.21 | | 8 | 112.8 | 4.44 | | 8 | 141.0 | 5.55 | | 8 | 10.8 | 0.43 |
| | 9 | 265.7 | 10.46 | | 9 | 218.6 | 8.61 | | 9 | 83.6 | 3.29 | | 9 | 70.6 | 2.78 |
| | 10 | 94.3 | 3.71 | | 10 | 26.4 | 1.04 | | 10 | 161.5 | 6.36 | | 10 | 55.9 | 2.20 |
| | 11 | 10.8 | 0.43 | | 11 | 7.0 | 0.28 | | 11 | 95.2 | 3.75 | | 11 | 55.7 | 2.19 |
| | 12 | 23.1 | 0.91 | | 12 | 40.9 | 1.61 | | 12 | 43.3 | 1.70 | | 12 | 9.2 | 0.36 |

# APPENDIX D

## EPIC Input Datasets for the BMP Demonstration Sites

### EPIC5300 DATA ASSEMBLY FORM

| | | | |
|---|---|---|---|
| 1.1 | Arroyo Colorado Project - Irrigated Demonstration Site 18:48 29oct97 | | TITLE(1) |
| 2.1 | bmpu · Grain Sorghum/Cotton, Olmito silty clay (BMP Site) 96-97 | | TITLE(2) |
| 3.1 | Wea. 9 TX BROWNSVILLE Wwi: 9 TX BROWNSVILLE W | | TITLE(3) |
| 4.1 | Number of years of simulation | 2 | NBYR |
| 4.2 | Starting date   Year | 1996 | IYR |
| 4.3 | Month | 1 | IMO |
| 4.4 | Day | 1 | IDA |
| 4.5 | Printout interval | 0 | NIPD |
| 4.6 | Output print code | 6 | IPD |
| 4.7 | Weather code | 12 | NGN |
| 4.8 | Number of times generator cycles | 0 | IGN |
| 4.9 | Day weather generator stops generating same weather | 0 | IGSD |
| 4.10 | Leap year considered | 0 | LPYR |
| 4.11 | Potential evaporation method code | 4 | IET |
| 4.12 | Curve number estimator (0-stochastic, >0 rigid) | 0 | ISCN |
| 4.13 | Graph Display (0-off, 1 on) | 1 | IGRAF |
| 4.14 | Output conversion code | 1 | ICODE |
| 4.15 | Peak rate estimate code | 0 | ITYP |
| 4.16 | Static soil code | 0 | ISTA |
| 4.17 | Automatic heat unit scheduling | 0 | IHUS |
| 4.18 | Number of cows | 0 | NCOW |
| 4.19 | Non varying CN--CN2 used for all storms | 0 | NVCN |
| 4.20 | Runoff (Q) estimation methodology | 0 | INFL |
| 4.21 | Pesticide Output in Mass and/or Conc | 0 | MASP |
| 5.1 | Watershed drainage area (ha) | 8.09 | WSA |
| 5.2 | Runoff curve number | 89.0 | CN2 |
| 5.3 | Channel Lengthl (Km) | .40 | CHL |
| 5.4 | Average channel slope (m/ m) | .00075 | CHS |
| 5.5 | Channel roughness factor(manning's N) | .0250 | CHN |
| 5.6 | Surface roughness factor(manning's N) | .1900 | SN |
| 5.7 | Peak runoff-rate rainfall-energy adjustment factor | 1.0 | APM |
| 5.8 | Latitude of watershed (degrees) | 26.10 | YLT |
| 5.9 | Average elevation of watershed (m) | 15.2 | ELEV |
| 5.10 | Water content of snow on ground at start of simulation (mm) | .0 | SNO |
| 6.1 | Average concentration of nitrogen in rainfall (g m$^{3}$) [PPM] | .8 | RCN |
| 6.2 | Number of years of cultivation before simulation starts (yr ) | 50.0 | RTN |
| 6.3 | CO2 concentration in atmosphere [PPM] | 330.0 | C02 |
| 6.4 | NO3 concentration in irrigation water [PPM] | .1 | CN03I |
| 6.5 | CSALT salt concentration in irrigation water [PPM] | 960.0 | CSALT |
| 6.6 | CHD Channel depth [m] | .152 | CHD |
| 6.7 | Drainage Area of a watershed feeding a Lagoon (ha) | .000 | DALG |
| 6.8 | Normal Lagoon Volume (mm) | .000 | VLGN |
| 6.9 | Maximum Lagoon Volume (mm) | .000 | VLGM |
| 6.10 | Lagoon input from wash water (m$^{3}$ /cow/day) | .000 | COWW |
| 7.1 | Slope length (m) | 402.3 | SL |
| 7.2 | Slope steepness (m /m) | .00075 | S |
| 7.3 | Erosion control practice | 1.00 | PEC |
| 7.4 | Water erosion equation | 3.00 | DRV |
| 7.5 | Parameter estimates for MUSI erosion equation | | BUS(1) |
| | | | BUS(2) |
| | | | BUS(3) |
| | | | BUS(4) |
| 8.3 | Number of years of max monthly 0.5 hour rainfall record | 8.0 | YWI |
| 8.4 | Coefficient used to establish wet dry probability | .0 | BTA |

| No. | Parameter | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Variable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.5 | Parameter used to modify exp rain distribution | | | | | | | | | | .0<br>100.0<br>100.0 | | | EXPK |
| 9.1 | Average monthly maximum air temperature (°C) | 20.60 | 22.60 | 25.80 | 29.10 | 31.40 | 33.60 | 34.80 | 35.10 | 32.80 | 29.70 | 24.70 | 22.00 | OBMX(1-12) |
| 10.1 | Average monthly minimum air temperature (°C) | 9.30 | 10.80 | 14.10 | 18.00 | 21.00 | 22.80 | 23.30 | 23.20 | 21.80 | 17.90 | 13.30 | 10.60 | OBMN(1-12) |
| 11.1 | Monthly standard deviation maximum air temperature (°C) | 6.70 | 6.10 | 5.20 | 3.90 | 2.80 | 2.30 | 2.20 | 2.50 | 3.10 | 3.80 | 6.50 | 6.20 | SDTMX(1-12) |
| 12.1 | Monthly standard deviation minimum air temperature (°C) | 6.00 | 5.70 | 5.30 | 4.20 | 3.00 | 2.10 | 1.40 | 1.40 | 2.40 | 4.00 | 5.70 | 5.80 | SDTMN(1-12) |
| 13.1 | Average monthly precipitation (mm) | 35.2 | 41.6 | 22.5 | 48.3 | 68.7 | 73.6 | 41.1 | 71.5 | 129.7 | 67.9 | 39.1 | 32.7 | RMO(1-12) |
| 14.1 | Monthly standard deviation of daily precipitation (mm) | 7.9 | 16.0 | 8.5 | 27.2 | 19.5 | 16.2 | 12.6 | 17.4 | 21.0 | 14.9 | 10.7 | 8.5 | RST2(1-12) |
| 15.1 | Monthly skew coefficient for daily precipitation | 4.58 | 7.54 | 3.45 | 6.07 | 3.36 | 2.41 | 4.54 | 3.64 | 3.10 | 2.74 | 2.70 | 4.08 | RST3(1-12) |
| 16.1 | Monthly probability of wet day after dry day | .171 | .145 | .107 | .103 | .132 | .130 | .117 | .138 | .221 | .148 | .142 | .151 | PRW1(1-12) |
| 17.1 | Monthly probability of wet day after wet day | .508 | .506 | .365 | .400 | .364 | .498 | .417 | .483 | .541 | .437 | .440 | .490 | PRW2(1-12) |
| 18.1 | Average number of days of rain per month | 8.00 | 6.40 | 4.50 | 4.40 | 5.30 | 6.20 | 5.20 | 6.50 | 9.70 | 6.40 | 6.10 | 7.10 | DAYP(1-12) |
| 19.1 | Monthly maximum 0.5 hour-rainfall for period of record (TP24) (mm) | 8.4 | 18.3 | 3.3 | 40.9 | 25.7 | 36.1 | 25.7 | 44.5 | 31.5 | 58.2 | 21.1 | 20.8 | WI(1-12) |
| 20.1 | Monthly average daily solar radiation (MJ/m² or ly) | 296 | 341. | 403. | 456. | 564. | 610. | 626. | 568. | 475. | 411. | 296. | 263. | OBSL(1-12) |
| 21.1 | Montly average relative humidity (fraction) | .76 | .75 | .72 | .72 | .74 | .73 | .72 | .71 | .73 | .73 | .76 | .75 | RH(1-12) |
| 22.1 | Field length (km) | | | | | | | | | | .40 | | | FL |
| 22.2 | Field width (km) | | | | | | | | | | .20 | | | FW |
| 22.3 | Clockwise angle of field from north (deg) | | | | | | | | | | 355.00 | | | ANG |
| 22.4 | Standing dead crop residue (t/ha) | | | | | | | | | | .00 | | | STD |
| 23.1 | Power of modified exponential distribution of wind speed | | | | | | | | | | .30 | | | UXP |
| 23.2 | Climate factor | | | | | | | | | | 350.<br>1.00 | | | DIAM |
| 24.1 | Average monthly wind velocity (m/s) | 5.24 | 5.51 | 5.97 | 6.27 | 5.92 | 5.45 | 5.13 | 4.64 | 4.24 | 4.33 | 4.82 | 4.85 | UAVM(1-12) |
| 25.1 | N wind during each month (%) | 9.0 | 9.0 | 6.0 | 4.0 | 2.0 | 1.0 | .0 | 2.0 | 5.0 | 7.0 | 8.0 | 9.0 | DIR1(1-12) |
| 26.1 | NNE wind during each month (%) | 4.0 | 4.0 | 4.0 | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 4.0 | 4.0 | 4.0 | 3.0 | DIR2(1-12) |
| 27.1 | NE wind during each month (%) | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 3.0 | 8.0 | 7.0 | 4.0 | 3.0 | DIR3(1-12) |
| 28.1 | ENE wind during each month (%) | 2.0 | 4.0 | 5.0 | 4.0 | 4.0 | 3.0 | 1.0 | 4.0 | 7.0 | 5.0 | 3.0 | 3.0 | DIR4(1-12) |
| 29.1 | E wind during each month (%) | 3.0 | 5.0 | 7.0 | 8.0 | 7.0 | 7.0 | 5.0 | 8.0 | 9.0 | 8.0 | 4.0 | 3.0 | DIR5(1-12) |
| 30.1 | ESE wind during each month (%) | 5.0 | 7.0 | 10.0 | 13.0 | 16.0 | 16.0 | 12.0 | 14.0 | 13.0 | 11.0 | 6.0 | 5.0 | DIR6(1-12) |
| 31.1 | SE wind during each month (%) | 13.0 | 15.0 | 19.0 | 26.0 | 34.0 | 36.0 | 35.0 | 29.0 | 16.0 | 17.0 | 12.0 | 11.0 | DIR7(1-12) |
| 32.1 | SSE wind during each month (%) | 17.0 | 17.0 | 20.0 | 22.0 | 20.0 | 22.0 | 31.0 | 23.0 | 11.0 | 11.0 | 15.0 | 14.0 | DIR8(1-12) |
| 33.1 | S wind during each month (%) | 10.0 | 9.0 | 9.0 | 7.0 | 5.0 | 6.0 | 11.0 | 10.0 | 6.0 | 5.0 | 10.0 | 12.0 | DIR9(1-12) |
| 34.1 | SSW wind during each month (%) | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 2.0 | 3.0 | DIR10(1-12) |
| 35.1 | SW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR11(1-12) |
| 36.1 | WSW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | DIR12(1-12) |
| 37.1 | W wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR13(1-12) |
| 38.1 | WNW wind during each month (%) | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | DIR14(1-12) |
| 39.1 | NW wind during each month (%) | 10.0 | 8.0 | 4.0 | 2.0 | 2.0 | 1.0 | 0 | 2.0 | 8.0 | 8.0 | 11.0 | 11.0 | DIR15(1-12) |
| 40.1 | NNW wind during each month (%) | 15.0 | 10.0 | 6.0 | 3.0 | 2.0 | 1.0 | .0 | 2.0 | 7.0 | 9.0 | 13.0 | 15.0 | DIR16(1-12) |
| 41.1 | Soil albedo | | | | | | | | | | .02 | | | SALB |
| 41.2 | Maxium number of soil layers | | | | | | | | | | 10. | | | TSLA |
| 41.3 | Minimum thickness of maxium layer (m) | | | | | | | | | | .00 | | | ZQT |
| 41.4 | Initial layer splitting thickness (cm) | | | | | | | | | | | | | ZTK |
| 41.5 | Minimum soil profile thickness (cm) | | | | | | | | | | | | | ZF |
| 41.6 | Initial soil water content-fraction of field capacity | | | | | | | | | | 1.00 | | | FFC |
| 41.7 | Minimum depth to water table (m) | | | | | | | | | | 1.60 | | | WTMN |
| 41.8 | Maximum depth to water table (m) | | | | | | | | | | 4.57 | | | WTMX |
| 41.9 | Initial depth to water table (m) | | | | | | | | | | 1.60 | | | WTBL |
| 41.10 | Soil weathering code | | | | | | | | | | 0. | | | XIDS |
| 41.11 | Time for sub surface flow travel time(d) | | | | | | | | | | 0. | | | RFTT |
| 42.1 | Depth from the surface to the bottom of the soil layer (m) | .010 | .860 | 1.600 | | | | | | | | | | Z(1-10) |
| 43.1 | Bulk density of the soil layer (t/m³) | 1.270 | 1.270 | 1.350 | | | | | | | | | | BD(1-10) |
| 44.1 | Wilting point (1500 kPa) (m/m) | .320 | .320 | .300 | | | | | | | | | | U(1-10) |
| 45.1 | Field capacity (33kPa) (m/m) | .480 | .480 | .440 | | | | | | | | | | FC(1-10) |
| 46.1 | Sand content (%) | 5.5 | 5.5 | 7.4 | | | | | | | | | | SAN(1-10) |
| 47.1 | Silt content (%) | 47.0 | 47.0 | 47.6 | | | | | | | | | | SIL(1-10) |
| 48.1 | Organic N concentration (g/t) [PPM] | 847. | 596. | | | | | | | | | | | WN(1-10) |
| 49.1 | Soil pH | 8.2 | 8.2 | 8.2 | | | | | | | | | | PH(1-10) |
| 50.1 | Sum of bases (cmol/kg) | | | | | | | | | | | | | SMB(1-10) |
| 51.1 | Organic carbon (%) | .51 | .42 | | | | | | | | | | | CBN(1-10) |
| 52.1 | Calcium carbonate (%) | | | | | | | | | | | | | CAC(1-10) |
| 53.1 | Cation exchange capacity (cmol/kg) | | | | | | | | | | | | | CEC(1-10) |
| 54.1 | Coarse fragment content (% vol) | | | 2.9 | | | | | | | | | | ROK(1-10) |
| 55.1 | Initial Nitrate concentration (g/t³) [PPM] | 5. | 5 | 5. | | | | | | | | | | WNO3(1-10) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 56.1 | Labile P concentration ($g/t^3$) [PPM] | 6. | 6. | | | O(1-10) |
| 57.1 | Crop residue (t/ha) | | | | | RSD(1-10) |
| 58.1 | Bulk density (oven dry) ($t/m^3$) | 1.70 | 1.70 | 1.75 | | BDD(1-10) |
| 59.1 | Phosphorus sorption ratio | | | | | PSP(1-10) |
| 60.1 | Saturated conductivity (mm/h) | .15 | .15 | .14 | | SC(1-10) |
| 61.1 | Fraction of storage interacting with NO3 leaching | 0. | 0. | 0. | | STFR(1-10) |
| 62.1 | Organic P concentration (g/t) [PPM] | 140. | 140. | | | WP(1-10) |
| 63.1 | Crop rotation duration (yr.) | | | | 2 | NRO |
| 63.2 | Rigid or variable irrigation | | | | 1 | NIRR |
| 63.3 | Irrigation code | | | | 2 | IRR |
| 63.4 | Minimum application interval for automatic irrigation (d) | | | | 0 | IRI |
| 63.5 | Minimum fertilizer application interval for automatic fertilizer (d) | | | | 0 | IFA |
| 63.6 | Liming code | | | | 1 | LM |
| 63.7 | Furrow dike code | | | | 1 | IFD |
| 63.8 | Drainage code | | | | 1600 | IDR |
| 63.9 | Automatic fertilizer or fertigation fertilizer file | | | | 0 | IDFT |
| 64.1 | Water stress factor to trigger automatic irrigation | | | | .00 | BIR |
| 64.2 | Irrigation runoff ratio | | | | .00 | EFI |
| 64.3 | Maximum annual irrigation volume allowed for each crop (mm) | | | | .00 | VIMX |
| 64.4 | Minimum single application volume automatic irrigation (mm) | | | | .00 | ARMN |
| 64.5 | Maximum single application volume automatic irrigation (mm) | | | | .00 | ARMX |
| 64.6 | N stress factor to trigger automatic fertilizer | | | | .00 | BFT |
| 64.7 | Amount of fertilizer (IDFT) per automatically scheduled application | | | | .00 | FNP |
| 64.8 | Maxium annual N fertilizer application for a crop (kg/ha) | | | | 99999.0 | FMX |
| 64.9 | Time required for drainage system to reduce stress (d) | | | | 3.50 | DRT |
| 64.10 | Fraction of furrow dike volume available for storage | | | | .99 | FDSF |

## 3 Management Information-Irrigation Fertilizer/Tillage Schedule
(One line for each operation and one section for each year of rotation)

| MON | DAY | COD | CRP/GRZ<br>FN<br>PST | MAT | PHU<br>FAP<br>LA<br>PCF | CND<br>FDP<br>PAR | WSF | QVOL | FPP | FNMX | HUSC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 15 | | | | | | | | | |
| 1 | 27 | 80 | | | | | | | | | |
| 2 | 1 | 72 | | 91.44 | | | | | | | |
| 2 | 27 | 71 | 67 | 175.00 | | | | | | | |
| 3 | 1 | 19 | | | | | | | | | |
| 3 | 1 | 2 | 3 | 2000.00 | | | | | | | |
| 4 | 1 | 71 | 67 | 105.00 | | | | | | | |
| 4 | 8 | 72 | | 91.44 | | | | | | | |
| 5 | 1 | 19 | | | | | | | | | |
| 5 | 7 | 72 | | 91.44 | | | | | | | |
| 7 | 7 | 51 | | | | | | | | | |
| 8 | 1 | 41 | | | | | | | | | |
| 8 | 1 | 16 | | | | | | | | | |
| 8 | 5 | 15 | | | | | | | | | |
| 8 | 6 | 80 | | | | | | | | | |
| 8 | 7 | 72 | | 152.40 | | | | | | | |
| | | | | | | | | | | | |
| 1 | 15 | 16 | | | | | | | | | |
| 1 | 17 | 15 | | | | | | | | | |
| 1 | 19 | 80 | | | | | | | | | |
| 1 | 23 | 72 | | 91.44 | | | | | | | |
| 3 | 18 | 71 | 67 | 210.00 | | | | | | | |
| 3 | 20 | 2 | 5 | 2900.00 | | | | | | | |
| 4 | 04 | 19 | | | | | | | | | |
| 4 | 08 | 72 | | 91.44 | | | | | | | |
| 5 | 06 | 19 | | | | | | | | | |
| 5 | 10 | 72 | | 91.44 | | | | | | | |
| 6 | 10 | 19 | | | | | | | | | |
| 6 | 14 | 72 | | 91.44 | | | | | | | |
| 6 | 20 | 71 | 67 | 140.00 | | | | | | | |
| 9 | 1 | 11 | 96 | 1.00 | 17 | | | | | | |
| 9 | 15 | 51 | | | | | | | | | |
| 9 | 16 | 41 | | | | | | | | | |
| 9 | 17 | 57 | | | | | | | | | |
| 9 | 18 | 15 | | | | | | | | | |
| 11 | 15 | 23 | | | | | | | | | |
| 12 | 15 | 23 | | | | | | | | | |

Month of the operation
Day of the operation
Operation/Tillage code number
RZ Crop identification number OR Grazing
Years necessary to mature or year until harvest (For trees only)
Potential Heat Units
Runoff curve number after this operation
Plant water stress factor
Fraction of original plant population
Maximum annual nitrogen fertilizer applied to a crop
Time of this operation as a fraction of the growing season or of the year if no crop is growing, using 0°C as the base temperature
Fertilizer ID number applied
Fertilizer application rate (Kg/ha-0% moisture)
Depth of fertilizer placement (mm)
Irrigation volume (mm)
Runoff VOL/VOL of irrigation water applied
Pesticide ID number
Pest control factor (fraction)
Pesticide application rate (Kg/ha or lbs/ac of active ingredient)

# IC5300 DATA ASSEMBLY FORM

| | | | |
|---|---|---|---|
| 1 | Arroyo Colorado Project - Irrigated Demonstration Site 12:41 7oct97 | | TITLE(1) |
| 1 | conir . Grain Sorghum/Cotton, Olmito silty clay (Control Site) 96-97 | | TITLE(2) |
| 1 | Wea 9 TX BROWNSVILLEWwi 9 TX BROWNSVILLE W | | TITLE(3) |
| 1 | Number of years of simulation | 2 | NBYR |
| 2 | Starting date - Year | 1996 | IYR |
| 3 | Month | 1 | IMO |
| 4 | Day | 1 | IDA |
| 5 | Printout interval | 0 | NIPD |
| 6 | Output print code | 6 | IPD |
| 7 | Weather code | 12 | NGN |
| 8 | Number of times generator cycles | 0 | IGN |
| 9 | Day weather generater stops generating same weather | 0 | IGSD |
| 10 | Leap year considered | 0 | LPYR |
| 11 | Potental evaporation method code | 4 | IET |
| 12 | Curve number estimator (0 stochastic , -0 rigid) | 0 | ISCN |
| 13 | Graph Display (0 off 1 on) | 1 | IGRAF |
| 14 | Output conversion code | 1 | ICODE |
| 15 | Peak rate estimate code | 0 | ITYP |
| 16 | Static soil code | 0 | ISTA |
| 17 | Automatic heat unit scheduling | 0 | IHUS |
| 18 | Number of cows | 0 | NCOW |
| 19 | Non varying CN -CN2 used for all storms | 0 | NVCN |
| 20 | Runoff (Q) estimation methodology | 0 | INFL |
| 21 | Pesticide Output in Mass and/or Conc | 0 | MASP |
| 1 | Watershed drainage area (ha) | 8.09 | WSA |
| 2 | Runoff curve number | 89.0 | CN2 |
| 3 | Channel Length1 (Km) | .40 | CHL |
| 4 | Average channel slope (m/ m) | .00075 | CHS |
| 5 | Channel roughness factor(manning's N) | .0250 | CHN |
| 6 | Surface roughness factor(manning's N) | .1900 | SN |
| 7 | Peak runoff rate rainfall-energy adjustment factor | 1.0 | APM |
| 8 | Latitude of watershed (degrees) | 26.10 | YLT |
| 9 | Average elevation of watershed (m) | 15.2 | ELEV |
| 10 | Water content of snow on ground at start of simulation (mm) | .0 | SNO |
| 1 | Average concentration of nitrogen in rainfall (g m$^3$) [PPM] | .8 | RCN |
| 2 | Number of years of cultivation before simulation starts (yr ) | 50.0 | RTN |
| 3 | CO2 concentration in atmosphere [PPM] | 330.0 | C02 |
| 4 | NO3 concentration in irrigation water [PPM] | .1 | CN03I |
| 5 | CSALT salt concentration in irrigation water [PPM] | 960.0 | CSALT |
| 6 | CHD Channel depth [m] | .152 | CHD |
| 7 | Drainage Area of a watershed feeding a Lagoon (ha) | .000 | DALG |
| 8 | Normal Lagoon Volume (mm) | .000 | VLGN |
| 9 | Maximum Lagoon Volume (mm) | .000 | VLGM |
| 10 | Lagoon input from wash water (m$^3$ /cow/day) | .000 | COWW |
| 1 | Slope length (m) | 402.3 | SL |
| 2 | Slope steepness (m /m) | .00075 | S |
| 3 | Erosion control practice | 1.00 | PEC |
| 4 | Water erosion equation | 3.00 | DRV |
| 5 | Parameter estimates for MUSI erosion equation | | BUS(1) |
| | | | BUS(2) |
| | | | BUS(3) |
| | | | BUS(4) |
| 3 | Number of years of max monthly 0.5 hour rainfall record | 8.0 | YWI |
| 4 | Coefficient use l to establish wet-dry probability | .0 | BTA |
| 5 | Parameter used to modify exp rain distribution | .0 | EXPK |
| | | 100.0 | |
| | | 100.0 | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Average monthly maximum air temperature (°C) | 20.60 | 22.60 | 25.80 | 29.10 | 31.40 | 33.60 | 34.80 | 35.10 | 32.80 | 29.70 | 24.70 | 22.00 | OBMX(1-12) |
| 10 1 | Average monthly minimum air temperature (°C) | 9.30 | 10.80 | 14.10 | 18.00 | 21.00 | 22.80 | 23.30 | 23.20 | 21.80 | 17.90 | 13.30 | 10.60 | OBMN(1-12) |
| 11 1 | Monthly standard deviation maximum air temperature (°C) | 6.70 | 6.10 | 5.20 | 3.90 | 2.80 | 2.30 | 2.20 | 2.50 | 3.10 | 3.80 | 6.50 | 6.20 | SDTMX(1-12) |
| 12 1 | Monthly standard deviation minimum air temperature (°C) | 6.00 | 5.70 | 5.30 | 4.20 | 3.00 | 2.10 | 1.40 | 1.40 | 2.40 | 4.00 | 5.70 | 5.80 | SDTMN(1-12) |
| 13 1 | Average monthly precipitation (mm) | 35.2 | 41.6 | 22.5 | 48.3 | 68.7 | 73.6 | 41.1 | 71.5 | 129.7 | 67.9 | 39.1 | 32.7 | RMO(1-12) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.1 | Monthly standard deviation of daily precipitation (mm) | 7.9 | 16.0 | 8.5 | 27.2 | 19.5 | 16.2 | 12.6 | 17.4 | 21.0 | 14.9 | 10.7 | 8.5 | RST2(1-12) |
| 15.1 | Monthly skew coefficient for daily precipitation | 4.58 | 7.54 | 3.45 | 6.07 | 3.36 | 2.41 | 4.54 | 3.64 | 3.10 | 2.74 | 2.70 | 4.08 | RST3(1-12) |
| 16.1 | Monthly probability of wet day after dry day | .171 | .145 | .107 | .103 | .132 | .130 | .117 | .138 | .221 | .148 | .142 | .151 | PRW1(1-12) |
| 17.1 | Monthly probability of wet day after wet day | .508 | .506 | .365 | .400 | .364 | .498 | .417 | 483 | 541 | 437 | 440 | 490 | PRW2(1-12) |
| 18.1 | Average number of days of rain per month | 8.00 | 6.40 | 4.50 | 4.40 | 5.30 | 6.20 | 5.20 | 6.50 | 9.70 | 6.40 | 6.10 | 7.10 | DAYP(1-12) |
| 19.1 | Monthly maximum 0.5 hour-rainfall for period of record (TP24) (mm) | 8.4 | 18.3 | 3.3 | 40.9 | 25.7 | 36.1 | 25.7 | 44.5 | 31.5 | 58.2 | 21.1 | 20.8 | WI(1-12) |
| 20.1 | Monthly average daily solar radiation (MJ/m$^2$ or ly) | 296. | 341. | 403. | 456. | 564. | 610. | 626. | 568. | 475. | 411. | 296. | 263. | OBSL(1-12) |
| 21.1 | Montly average relative humidity (fraction) | .76 | .75 | .72 | .72 | .74 | .73 | .72 | .71 | .73 | .73 | .76 | .75 | RH(1-12) |
| 22.1 | Field length (km) | | | | | | | | | | .40 | | | FL |
| 22.2 | Field width (km) | | | | | | | | | | .20 | | | FW |
| 22.3 | Clockwise angle of field from north (deg) | | | | | | | | | | 355.00 | | | ANG |
| 22.4 | Standing dead crop residue (t/ha) | | | | | | | | | | .00 | | | STD |
| 23.1 | Power of modified exponential distribution of wind speed | | | | | | | | | | .30 | | | UXP |
| 23.2 | Climate factor | | | | | | | | | | 350. | | | DIAM |
| | | | | | | | | | | | 1.00 | | | |
| 24.1 | Average monthly wind velocity (m/s) | 5.24 | 5.51 | 5.97 | 6.27 | 5.92 | 5.45 | 5.13 | 4.64 | 4.24 | 4.33 | 4.82 | 4.85 | UAVM(1-12) |
| 25.1 | N wind during each month (%) | 9.0 | 9.0 | 6.0 | 4.0 | 2.0 | 1.0 | .0 | 2.0 | 5.0 | 7.0 | 8.0 | 9.0 | DIR1(1-12) |
| 26.1 | NNE wind during each month (%) | 4.0 | 4.0 | 4.0 | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 4.0 | 4.0 | 4.0 | 3.0 | DIR2(1-12) |
| 27.1 | NE wind during each month (%) | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 3.0 | 8.0 | 7.0 | 4.0 | 3.0 | DIR3(1-12) |
| 28.1 | ENE wind during each month (%) | 2.0 | 4.0 | 5.0 | 4.0 | 4.0 | 3.0 | 1.0 | 4.0 | 7.0 | 5.0 | 3.0 | 3.0 | DIR4(1-12) |
| 29.1 | E wind during each month (%) | 3.0 | 5.0 | 7.0 | 8.0 | 7.0 | 7.0 | 5.0 | 8.0 | 9.0 | 8.0 | 4.0 | 3.0 | DIR5(1-12) |
| 30.1 | ESE wind during each month (%) | 5.0 | 7.0 | 10.0 | 13.0 | 16.0 | 16.0 | 12.0 | 14.0 | 13.0 | 11.0 | 6.0 | 5.0 | DIR6(1-12) |
| 31.1 | SE wind during each month (%) | 13.0 | 15.0 | 19.0 | 26.0 | 34.0 | 36.0 | 35.0 | 29.0 | 16.0 | 17.0 | 12.0 | 11.0 | DIR7(1-12) |
| 32.1 | SSE wind during each month (%) | 17.0 | 17.0 | 20.0 | 22.0 | 20.0 | 22.0 | 31.0 | 23.0 | 11.0 | 11.0 | 15.0 | 14.0 | DIR8(1-12) |
| 33.1 | S wind during each month (%) | 10.0 | 9.0 | 9.0 | 7.0 | 5.0 | 6.0 | 11.0 | 10.0 | 6.0 | 5.0 | 10.0 | 12.0 | DIR9(1-12) |
| 34.1 | SSW wind during each month (%) | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 2.0 | 3.0 | DIR10(1-12) |
| 35.1 | SW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR11(1-12) |
| 36.1 | WSW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | DIR12(1-12) |
| 37.1 | W wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR13(1-12) |
| 38.1 | WNW wind during each month (%) | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | DIR14(1-12) |
| 39.1 | NW wind during each month (%) | 10.0 | 8.0 | 4.0 | 2.0 | 2.0 | 1.0 | .0 | 2.0 | 8.0 | 8.0 | 11.0 | 11.0 | DIR15(1-12) |
| 40.1 | NNW wind during each month (%) | 15.0 | 10.0 | 6.0 | 3.0 | 2.0 | 1.0 | .0 | 2.0 | 7.0 | 9.0 | 13.0 | 15.0 | DIR16(1-12) |
| 41.1 | Soil albedo | | | | | | | | | | 02 | | | SALB |
| 41.2 | Maxium number of soil layers | | | | | | | | | | 10. | | | TSLA |
| 41.3 | Minimum thickness of maxium layer (m) | | | | | | | | | | 00 | | | ZQT |
| 41.4 | Initial layer splitting thickness (cm) | | | | | | | | | | | | | ZTK |
| 41.5 | Minimum soil profile thickness (cm) | | | | | | | | | | | | | ZF |
| 41.6 | Initial soil water content fraction of field capacity | | | | | | | | | | 1.00 | | | FFC |
| 41.7 | Minimum depth to water table (m) | | | | | | | | | | 1.60 | | | WTMN |
| 41.8 | Maximum depth to water table (m) | | | | | | | | | | 4.57 | | | WTMX |
| 41.9 | Initial depth to water table (m) | | | | | | | | | | 1.60 | | | WTBL |
| 41.10 | Soil weathering code | | | | | | | | | | 0. | | | XIDS |
| 41.11 | Time for sub surface flow travel time(d) | | | | | | | | | | 0. | | | RFTT |
| 42.1 | Depth from the surface to the bottom of the soil layer (m) | .010 | .860 | 1.600 | | | | | | | | | | Z(1-10) |
| 43.1 | Bulk density of the soil layer (t/m$^3$) | 1.270 | 1.270 | 1.350 | | | | | | | | | | BD(1-10) |
| 44.1 | Wilting point (1500 kPa) (m/m) | .320 | .320 | .300 | | | | | | | | | | U(1-10) |
| 45.1 | Field capacity (33kPa) (m/m) | .480 | 480 | .440 | | | | | | | | | | FC(1-10) |
| 46.1 | Sand content (%) | 5.5 | 5.5 | 7.4 | | | | | | | | | | SAN(1-10) |
| 47.1 | Silt content (%) | 47.0 | 47.0 | 47.6 | | | | | | | | | | SIL(1-10) |
| 48.1 | Organic N concentration (g/t) [PPM] | 847. | 596. | | | | | | | | | | | WN(1-10) |
| 49.1 | Soil pH | 8.2 | 8.2 | 8.2 | | | | | | | | | | PH(1-10) |
| 50.1 | Sum of bases (cmol/kg) | | | | | | | | | | | | | SMB(1-10) |
| 51.1 | Organic carbon (%) | .51 | .42 | | | | | | | | | | | CBN(1-10) |
| 52.1 | Calcium carbonate (%) | | | | | | | | | | | | | CAC(1-10) |
| 53.1 | Cation exchange capacity (cmol/kg) | | | | | | | | | | | | | CEC(1-10) |
| 54.1 | Coarse fragment content (% vol) | | | 2.9 | | | | | | | | | | ROK(1-10) |
| 55.1 | Initial Nitrate concentration (g/t$^3$) [PPM] | 5. | 5. | 5. | | | | | | | | | | WNO3(1-10) |
| 56.1 | Labile P concentration (g/t$^3$) [PPM] | 6. | 6 | | | | | | | | | | | O(1-10) |
| 57.1 | Crop residue (t/ha) | | | | | | | | | | | | | RSD(1-10) |
| 58.1 | Bulk density (oven dry) (t/m$^3$) | 1.70 | 1.70 | 1.75 | | | | | | | | | | BDD(1-10) |
| 59.1 | Phosphorus sorption ratio | | | | | | | | | | | | | PSP(1-10) |
| 60.1 | Saturated conductivity (mm/h) | .15 | 15 | .14 | | | | | | | | | | SC(1-10) |
| 61.1 | Fraction of storage interacting with NO3 leaching | 0 | 0. | 0. | | | | | | | | | | STFR(1-10) |
| 62.1 | Organic P concentration (g/t) [PPM] | 140 | 140. | | | | | | | | | | | WP(1-10) |
| 63.1 | Crop rotation duration (yr.) | | | | | | | | | | 2 | | | NRO |
| 63.2 | Rigid or variable irrigation | | | | | | | | | | 1 | | | NIRR |
| 63.3 | Irrigation code | | | | | | | | | | 2 | | | IRR |

| | | | | |
|---|---|---|---|---|
| 6.3.4 | Minimum application interval for automatic irrigation (d) | 0 | IRI |
| 6.3.5 | Minimum fertilizer application interval for automatic fertilizer (d) | 0 | IFA |
| 6.3.6 | Liming code | 1 | LM |
| 6.3.7 | Furrow dike code | 1 | IFD |
| 6.3.8 | Drainage code | 1600 | IDR |
| 6.3.9 | Automatic fertilizer or fertigation fertilizer file | 0 | IDFT |
| 6.4.1 | Water stress factor to trigger automatic irrigation | .00 | BIR |
| 6.4.2 | Irrigation runoff ratio | .00 | EFI |
| 6.4.3 | Maximum annual irrigation volume allowed for each crop (mm) | .00 | VIMX |
| 6.4.4 | Minimum single application volume automatic irrigation (mm) | .00 | ARMN |
| 6.4.5 | Maximum single application volume automatic irrigation (mm) | .00 | ARMX |
| 6.4.6 | N stress factor to trigger automatic fertilizer | .00 | BFT |
| 6.4.7 | Amount of fertilizer (IDFT) per automatically scheduled application | .00 | FNP |
| 6.4.8 | Maximum annual N fertilizer application for a crop (kg/ha) | 99999.0 | FMX |
| 6.4.9 | Time required for drainage system to reduce stress (d) | 3.50 | DRT |
| 6.4.10 | Fraction of furrow dike volume available for storage | .99 | FDSF |

## 8.3 Management Information-Irrigation Fertilizer/Tillage Schedule
## (One line for each operation and one section for each year of rotation)

| MON | DAY | COD | CRP/GRZ<br>FN<br><br>PST | MAT | PHU<br>FAP<br>LA<br>PCF | CND<br>FDP<br><br>PAR | WSF<br><br><br>QVOL | FPP | FNMX | HUSC |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 15 | | | | | | | | |
| 1 | 27 | 80 | | | | | | | | |
| 2 | 1 | 72 | | 91.44 | | | | | | |
| 2 | 27 | 71 | 67 | 350.00 | | | | | | |
| 3 | 1 | 19 | | | | | | | | |
| 3 | 1 | 2 | 3 | 2000.00 | | | | | | |
| 4 | 10 | 72 | | 91.44 | | | | | | |
| 5 | 1 | 19 | | | | | | | | |
| 5 | 10 | 72 | | 91.44 | | | | | | |
| 7 | 7 | 51 | | | | | | | | |
| 8 | 1 | 41 | | | | | | | | |
| 8 | 1 | 16 | | | | | | | | |
| 8 | 5 | 15 | | | | | | | | |
| 8 | 6 | 80 | | | | | | | | |
| 8 | 7 | 72 | | 152.40 | | | | | | |
| 1 | 15 | 16 | | | | | | | | |
| 1 | 17 | 15 | | | | | | | | |
| 1 | 19 | 80 | | | | | | | | |
| 1 | 23 | 72 | | 91.44 | | | | | | |
| 3 | 18 | 71 | 67 | 350.00 | | | | | | |
| 3 | 20 | 2 | 5 | 2900.00 | | | | | | |
| 4 | 04 | 19 | | | | | | | | |
| 4 | 08 | 72 | | 91.44 | | | | | | |
| 5 | 06 | 19 | | | | | | | | |
| 5 | 10 | 72 | | 91.44 | | | | | | |
| 6 | 10 | 19 | | | | | | | | |
| 6 | 14 | 72 | | 91.44 | | | | | | |
| 9 | 1 | 11 | 96 | 1.00 | 17 | | | | | |
| 9 | 15 | 51 | | | | | | | | |
| 9 | 16 | 41 | | | | | | | | |
| 9 | 17 | 57 | | | | | | | | |
| 9 | 18 | 15 | | | | | | | | |
| 11 | 15 | 23 | | | | | | | | |
| 12 | 15 | 23 | | | | | | | | |

| | |
|---|---|
| MON = | Month of the operation |
| DAY = | Day of the operation |
| COD = | Operation/Tillage code number |
| CRP/GRZ = | Crop identification number OR Grazing |
| MAT = | Years necessary to mature or year until harvest. (For trees only) |
| PHU = | Potential Heat Units |
| CND = | Runoff curve number after this operation |
| WSF = | Plant water stress factor |
| FPP = | Fraction of original plant population |
| FNMX = | Maximum annual nitrogen fertilizer applied to a crop |
| HUSC = | Time of this operation as a fraction of the growing season or of the year if no crop is growing; using 0°C as the base temperature |
| FN = | Fertilizer ID number applied |
| FAP = | Fertilizer application rate (Kg/ha-0% moisture) |
| FDP = | Depth of fertilizer placement (mm) |
| IA = | Irrigation volume (mm) |
| QVOL = | Runoff VOL/VOL of irrigation water applied |
| PST = | Pesticide ID number |
| PCF = | Pest control factor (fraction) |
| PAR = | Pesticide application rate (Kg/ha or lbs/ac of active ingredient) |

# EPIC5300 DATA ASSEMBLY FORM

| | | | |
|---|---|---|---|
| 1.1 | Arroyo Colorado Project - Dryland Demonstration Site 12:28 29oct97 | | TITLE(1) |
| 2.1 | bmpdr : Grain Sorghum/Cotton, Hidalgo Silty Clay Loam (BMP Site) 96-97 | | TITLE(2) |
| 3.1 | Wea: 9 TX BROWNSVILLE Wwi. 9 TX BROWNSVILLE W | | TITLE(3) |
| 4.1 | Number of years of simulation | 2 | NBYR |
| 4.2 | Starting date - Year | 1996 | IYR |
| 4.3 | Month | 1 | IMO |
| 4.4 | Day | 1 | IDA |
| 4.5 | Printout interval | 0 | NIPD |
| 4.6 | Output print code | 6 | IPD |
| 4.7 | Weather code | 12 | NGN |
| 4.8 | Number of times generator cycles | 0 | IGN |
| 4.9 | Day weather generator stops generating same weather | 0 | IGSD |
| 4.10 | Leap year considered | 0 | LPYR |
| 4.11 | Potential evaporation method code | 4 | IET |
| 4.12 | Curve number estimator (0-stochastic, >0-rigid) | 0 | ISCN |
| 4.13 | Graph Display (0-off, 1-on) | 1 | IGRAF |
| 4.14 | Output conversion code | 1 | ICODE |
| 4.15 | Peak rate estimate code | 0 | ITYP |
| 4.16 | Static soil code | 0 | ISTA |
| 4.17 | Automatic heat unit scheduling | 0 | IHUS |
| 4.18 | Number of cows | 0 | NCOW |
| 4.19 | Non-varying CN--CN2 used for all storms | 0 | NVCN |
| 4.20 | Runoff (Q) estimation methodology | 0 | INFL |
| 4.21 | Pesticide Output in Mass and/or Conc | 0 | MASP |
| 5.1 | Watershed drainage area (ha) | 6.07 | WSA |
| 5.2 | Runoff curve number | 72.0 | CN2 |
| 5.3 | Channel Lengthl (Km) | .35 | CHL |
| 5.4 | Average channel slope (m/ m) | .00075 | CHS |
| 5.5 | Channel roughness factor(manning's N) | .0900 | CHN |
| 5.6 | Surface roughness factor(manning's N) | .0900 | SN |
| 5.7 | Peak runoff-rate rainfall-energy adjustment factor | 1.0 | APM |
| 5.8 | Latitude of watershed (degrees) | 26.27 | YLT |
| 5.9 | Average elevation of watershed (m) | 7.0 | ELEV |
| 5.10 | Water content of snow on ground at start of simulation (mm) | .0 | SNO |
| 6.1 | Average concentration of nitrogen in rainfall ($g\ m^3$) [PPM] | .8 | RCN |
| 6.2 | Number of years of cultivation before simulation starts (yr.) | 50.0 | RTN |
| 6.3 | CO2 concentration in atmosphere [PPM] | 330.0 | C02 |
| 6.4 | NO3 concentration in irrigation water [PPM] | 1 | CN03I |
| 6.5 | CSALT salt concentration in irrigation water [PPM] | 960.0 | CSALT |
| 6.6 | CHD Channel depth [m] | .152 | CHD |
| 6.7 | Drainage Area of a watershed feeding a Lagoon (ha) | .000 | DALG |
| 6.8 | Normal Lagoon Volume (mm) | .000 | VLGN |
| 6.9 | Maximum Lagoon Volume (mm) | .000 | VLGM |
| 6.10 | Lagoon input from wash water ($m^3$/cow/day) | .000 | COWW |
| 7.1 | Slope length (m) | 348.4 | SL |
| 7.2 | Slope steepness (m /m) | .00075 | S |
| 7.3 | Erosion control practice | 1.00 | PEC |
| 7.4 | Water erosion equation | 3.00 | DRV |
| 7.5 | Parameter estimates for MUSI erosion equation | | BUS(1) |
| | | | BUS(2) |
| | | | BUS(3) |
| | | | BUS(4) |
| 8.3 | Number of years of max monthly 0.5 hour rainfall record | 8.0 | YWI |
| 8.4 | Coefficient used to establish wet-dry probability | .0 | BTA |
| 8.5 | Parameter used to modify exp rain distribution | .0 | EXPK |
| | | 100.0 | |
| | | 100.0 | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.1 | Average monthly maximum air temperature (°C) | 20.60 | 22.60 | 25.80 | 29.10 | 31.40 | 33.60 | 34.80 | 35.10 | 32.80 | 29.70 | 24.70 | 22.00 | OBMX(1-12) |
| 10.1 | Average monthly minimum air temperature (°C) | 9.30 | 10.80 | 14.10 | 18.00 | 21.00 | 22.80 | 23.30 | 23.20 | 21.80 | 17.90 | 13.30 | 10.60 | OBMN(1-12) |
| 11.1 | Monthly standard deviation maximum air temperature (°C) | 6.70 | 6.10 | 5.20 | 3.90 | 2.80 | 2.30 | 2.20 | 2.50 | 3.10 | 3.80 | 6.50 | 6.20 | SDTMX(1-12) |
| 12.1 | Monthly standard deviation minimum air temperature (°C) | 6.00 | 5.70 | 5.30 | 4.20 | 3.00 | 2.10 | 1.40 | 1.40 | 2.40 | 4.00 | 5.70 | 5.80 | SDTMN(1-12) |
| 13.1 | Average monthly precipitation (mm) | 35.2 | 41.6 | 22.5 | 48.3 | 68.7 | 73.6 | 41.1 | 71.5 | 129.7 | 67.9 | 39.1 | 32.7 | RMO(1-12) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.1 | Monthly standard deviation of daily precipitation (mm) | 7.9 | 16.0 | 8.5 | 27.2 | 19.5 | 16.2 | 12.6 | 17.4 | 21.0 | 14.9 | 10.7 | 8.5 | RST2(1-12) |
| 15.1 | Monthly skew coefficient for daily precipitation | 4.58 | 7.54 | 3.45 | 6.07 | 3.36 | 2.41 | 4.54 | 3.64 | 3.10 | 2.74 | 2.70 | 4.08 | RST3(1-12) |
| 16.1 | Monthly probability of wet day after dry day | .171 | .145 | .107 | .103 | .132 | .130 | .117 | .138 | .221 | .148 | .142 | .151 | PRW1(1-12) |
| 17.1 | Monthly probability of wet day after wet day | .508 | .506 | .365 | .400 | .364 | .498 | .417 | .483 | .541 | .437 | .440 | .490 | PRW2(1-12) |
| 18.1 | Average number of days of rain per month | 8.00 | 6.40 | 4.50 | 4.40 | 5.30 | 6.20 | 5.20 | 6.50 | 9.70 | 6.40 | 6.10 | 7.10 | DAYP(1-12) |
| 19.1 | Monthly maximum 0.5 hour-rainfall for period of record (TP24) (mm) | 8.4 | 18.3 | 3.3 | 40.9 | 25.7 | 36.1 | 25.7 | 44.5 | 31.5 | 58.2 | 21.1 | 20.8 | WI(1-12) |
| 20.1 | Monthly average daily solar radiation (MJ/m$^2$ or ly) | 296 | 341. | 403. | 456. | 564. | 610. | 626 | 568. | 475 | 411. | 296. | 263. | OBSL(1-12) |
| 21.1 | Monily average relative humidity (fraction) | .76 | .75 | .72 | .72 | .74 | .73 | .72 | .71 | .73 | .73 | .76 | .75 | RH(1-12) |
| 22.1 | Field length (km) | | | | | | | | | | .35 | | | FL |
| 22.2 | Field width (km) | | | | | | | | | | .17 | | | FW |
| 22.3 | Clockwise angle of field from north (deg) | | | | | | | | | | 355.00 | | | ANG |
| 22.4 | Standing dead crop residue (t/ha) | | | | | | | | | | .00 | | | STD |
| 23.1 | Power of modified exponential distribution of wind speed | | | | | | | | | | .30 | | | UXP |
| 23.2 | Climate factor | | | | | | | | | | 350. | | | DIAM |
| | | | | | | | | | | | .00 | | | |
| 24.1 | Average monthly wind velocity (m/s) | 5.24 | 5.51 | 5.97 | 6.27 | 5.92 | 5.45 | 5.13 | 4.64 | 4.24 | 4.33 | 4.82 | 4.85 | UAVM(1-12) |
| 25.1 | N wind during each month (%) | 9.0 | 9.0 | 6.0 | 4.0 | 2.0 | 1.0 | .0 | 2.0 | 5.0 | 7.0 | 8.0 | 9.0 | DIR1(1-12) |
| 26.1 | NNE wind during each month (%) | 4.0 | 4.0 | 4.0 | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 4.0 | 4.0 | 4.0 | 3.0 | DIR2(1-12) |
| 27.1 | NE wind during each month (%) | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 3.0 | 8.0 | 7.0 | 4.0 | 3.0 | DIR3(1-12) |
| 28.1 | ENE wind during each month (%) | 2.0 | 4.0 | 5.0 | 4.0 | 4.0 | 3.0 | 1.0 | 4.0 | 7.0 | 5.0 | 3.0 | 3.0 | DIR4(1-12) |
| 29.1 | E wind during each month (%) | 3.0 | 5.0 | 7.0 | 8.0 | 7.0 | 7.0 | 5.0 | 8.0 | 9.0 | 8.0 | 4.0 | 3.0 | DIR5(1-12) |
| 30.1 | ESE wind during each month (%) | 5.0 | 7.0 | 10.0 | 13.0 | 16.0 | 16.0 | 12.0 | 14.0 | 13.0 | 11.0 | 6.0 | 5.0 | DIR6(1-12) |
| 31.1 | SE wind during each month (%) | 13.0 | 15.0 | 19.0 | 26.0 | 34.0 | 36.0 | 35.0 | 29.0 | 16.0 | 17.0 | 12.0 | 11.0 | DIR7(1-12) |
| 32.1 | SSE wind during each month (%) | 17.0 | 17.0 | 20.0 | 22.0 | 20.0 | 22.0 | 31.0 | 23.0 | 11.0 | 11.0 | 15.0 | 14.0 | DIR8(1-12) |
| 33.1 | S wind during each month (%) | 10.0 | 9.0 | 9.0 | 7.0 | 5.0 | 6.0 | 11.0 | 10.0 | 6.0 | 5.0 | 10.0 | 12.0 | DIR9(1-12) |
| 34.1 | SSW wind during each month (%) | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 2.0 | 3.0 | DIR10(1-12) |
| 35.1 | SW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR11(1-12) |
| 36.1 | WSW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | DIR12(1-12) |
| 37.1 | W wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | 0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR13(1-12) |
| 38.1 | WNW wind during each month (%) | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | DIR14(1-12) |
| 39.1 | NW wind during each month (%) | 10.0 | 8.0 | 4.0 | 2.0 | 2.0 | 1.0 | 0 | 2.0 | 8.0 | 8.0 | 11.0 | 11.0 | DIR15(1-12) |
| 40.1 | NNW wind during each month (%) | 15.0 | 10.0 | 6.0 | 3.0 | 2.0 | 1.0 | .0 | 2.0 | 7.0 | 9.0 | 13.0 | 15.0 | DIR16(1-12) |
| 41.1 | Soil albedo | | | | | | | | | | .02 | | | SALB |
| 41.2 | Maxium number of soil layers | | | | | | | | | | 10. | | | TSLA |
| 41.3 | Minimum thickness of maxium layer (m) | | | | | | | | | | .00 | | | ZQT |
| 41.4 | Initial layer splitting thickness (cm) | | | | | | | | | | | | | ZTK |
| 41.5 | Minimum soil profile thickness (cm) | | | | | | | | | | | | | ZF |
| 41.6 | Initial soil water content-fraction of field capacity | | | | | | | | | | .50 | | | FFC |
| 41.7 | Minimum depth to water table (m) | | | | | | | | | | 1.60 | | | WTMN |
| 41.8 | Maximum depth to water table (m) | | | | | | | | | | 4.57 | | | WTMX |
| 41.9 | Initial depth to water table (m) | | | | | | | | | | 4.27 | | | WTBL |
| 41.10 | Soil weathering code | | | | | | | | | | 0. | | | XIDS |
| 41.11 | Time for sub surface flow travel time(d) | | | | | | | | | | 0. | | | RFTT |
| 42.1 | Depth from the surface to the bottom of the soil layer (m) | .010 | .430 | .710 | 2.030 | | | | | | | | | Z(1-10) |
| 43.1 | Bulk density of the soil layer (t/m$^3$) | 1.430 | 1.430 | 1.580 | 1.600 | | | | | | | | | BD(1-10) |
| 44.1 | Wilting point (1500 kPa) (m/m) | .170 | .170 | .190 | .190 | | | | | | | | | U(1-10) |
| 45.1 | Field capacity (33kPa) (m/m) | .310 | .310 | .310 | .310 | | | | | | | | | FC(1-10) |
| 46.1 | Sand content (%) | 57.0 | 57.0 | 55.5 | 53.9 | | | | | | | | | SAN(1-10) |
| 47.1 | Silt content (%) | 18.0 | 18.0 | 17.5 | 17.1 | | | | | | | | | SIL(1-10) |
| 48.1 | Organic N concentration (g/t) [PPM] | | 458. | 913. | 351 | | | | | | | | | WN(1-10) |
| 49.1 | Soil pH | 8.2 | 8.2 | 8.2 | 8.2 | | | | | | | | | PH(1-10) |
| 50.1 | Sum of bases (cmol/kg) | | | | | | | | | | | | | SMB(1-10) |
| 51.1 | Organic carbon (%) | .63 | .42 | .42 | .13 | | | | | | | | | CBN(1-10) |
| 52.1 | Calcium carbonate (%) | | | | | | | | | | | | | CAC(1-10) |
| 53.1 | Cation exchange capacity (cmol/kg) | | | | | | | | | | | | | CEC(1-10) |
| 54.1 | Coarse fragment content (% vol) | 1.4 | 1.4 | 1.3 | 5.4 | | | | | | | | | ROK(1-10) |
| 55.1 | Initial Nitrate concentration (g/t$^3$) [PPM] | 1 | 9. | 9. | 7. | | | | | | | | | WNO3(1-10) |
| 56.1 | Labile P concentration (g/t$^3$) [PPM] | 160. | 191. | | | | | | | | | | | O(1-10) |
| 57.1 | Crop residue (t/ha) | | | | | | | | | | | | | RSD(1-10) |
| 58.1 | Bulk density (oven dry) (t/m$^3$) | 1.57 | 1.57 | 1.72 | 1.75 | | | | | | | | | BDD(1-10) |
| 59.1 | Phosphorus sorption ratio | | | | | | | | | | | | | PSP(1-10) |
| 60.1 | Saturated conductivity (mm/h) | 11.76 | 11.76 | 5.93 | 4.57 | | | | | | | | | SC(1-10) |
| 61.1 | Fraction of storage interacting with NO3 leaching | 0 | 0. | 0. | 0 | | | | | | | | | STFR(1-10) |
| 62.1 | Organic P concentration (g/t) [PPM] | | 98 | 149. | 85 | | | | | | | | | WP(1-10) |
| 63.1 | Crop rotation duration (yr.) | | | | | | | | | | 2 | | | NRO |
| 63.2 | Rigid or variable irrigation | | | | | | | | | | 1 | | | NIRR |
| 63.3 | Irrigation code | | | | | | | | | | 0 | | | IRR |

| | | | |
|---|---|---|---|
| 63.4 | Minimum application interval for automatic irrigation (d) | 0 | IRI |
| 63.5 | Minimum fertilizer application interval for automatic fertilizer (d) | 0 | IFA |
| 63.6 | Liming code | 1 | LM |
| 63.7 | Furrow dike code | 0 | IFD |
| 63.8 | Drainage code | 0 | IDR |
| 63.9 | Automatic fertilizer or fertigation fertilizer file | 0 | IDFT |
| 64.1 | Water stress factor to trigger automatic irrigation | .00 | BIR |
| 64.2 | Irrigation runoff ratio | .00 | EFI |
| 64.3 | Maximum annual irrigation volume allowed for each crop (mm) | .00 | VIMX |
| 64.4 | Minimum single application volume automatic irrigation (mm) | .00 | ARMN |
| 64.5 | Maximum single application volume automatic irrigation (mm) | .00 | ARMX |
| 64.6 | N stress factor to trigger automatic fertilizer | .00 | BFT |
| 64.7 | Amount of fertilizer (IDFT) per automatically scheduled application | .00 | FNP |
| 64.8 | Maxium annual N fertilizer application for a crop (kg/ha) | 99999.0 | FMX |
| 64.9 | Time required for drainage system to reduce stress (d) | .00 | DRT |
| 64.10 | Fraction of furrow dike volume available for storage | .00 | FDSF |

## .3 Management Information-Irrigation Fertilizer/Tillage Schedule
## (One line for each operation and one section for each year of rotation)

| MON | DAY | COD | CRP/GRZ<br>FN<br>PST | MAT | PHU<br>FAP<br>LA<br>PCF | CND<br>FDP<br>PAR | WSF | QVOL | FPP | FNMX | HUSC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 15 | | | | | | | | | |
| 1 | 27 | 80 | | | | | | | | | |
| 2 | 1 | 71 | 67 | 210.00 | 85.00 | | | | | | |
| 2 | 1 | 19 | | | | | | | | | |
| 2 | 13 | 2 | 3 | 2000.00 | | | | | | | |
| 4 | 15 | 11 | 3 | .90 | 84 | | | | | | |
| 5 | 1 | 19 | | | | | | | | | |
| 6 | 15 | 51 | | | | | | | | | |
| 7 | 20 | 32 | | | | | | | | | |
| 9 | 1 | 11 | 204 | .90 | 1.12 | | | | | | |
| 10 | 19 | 41 | | | | | | | | | |
| 10 | 20 | 57 | | | | | | | | | |
| 10 | 25 | 22 | | | | | | | | | |
| 2 | 19 | 19 | | | | | | | | | |
| 2 | 19 | 80 | | | | | | | | | |
| 3 | 18 | 71 | 67 | 175.00 | 85.0 | | | | | | |
| 4 | 23 | 2 | 5 | 2900.00 | | | | | | | |
| 6 | 5 | 19 | | | | | | | | | |
| 6 | 6 | 71 | 67 | 175.00 | 85.0 | | | | | | |
| 9 | 1 | 11 | 96 | 1.00 | .17 | | | | | | |
| 9 | 15 | 51 | | | | | | | | | |
| 9 | 16 | 41 | | | | | | | | | |
| 9 | 17 | 57 | | | | | | | | | |
| 9 | 18 | 15 | | | | | | | | | |
| 11 | 15 | 23 | | | | | | | | | |
| 12 | 15 | 23 | | | | | | | | | |

| | |
|---|---|
| MON = | Month of the operation |
| DAY = | Day of the operation |
| COD = | Operation/Tillage code number |
| CRP/GRZ = | Crop identification number OR Grazing |
| MAT = | Years necessary to mature or year until harvest. (For trees only) |
| PHU = | Potential Heat Units |
| CND = | Runoff curve number after this operation |
| WSF = | Plant water stress factor |
| FPP = | Fraction of original plant population |
| FNMX = | Maximum annual nitrogen fertilizer applied to a crop |
| HUSC = | Time of this operation as a fraction of the growing season or of the year if no crop is growing; using 0°C as the base temperature |
| FN = | Fertilizer ID number applied |
| FAP = | Fertilizer application rate (Kg/ha-0% moisture) |
| FDP = | Depth of fertilizer placement (mm) |
| IA = | Irrigation volume (mm) |
| QVOL = | Runoff VOL/VOL of irrigation water applied |
| PST = | Pesticide ID number |
| PCF = | Pest control factor (fraction) |
| PAR = | Pesticide application rate (Kg/ha or lbs/ac of active ingredient) |

# PIC5300 DATA ASSEMBLY FORM

| | | | |
|---|---|---|---|
| 1 1 | Arroyo Colorado Project - Dryland Demonstration Site 14:51 29oct97 | | TITLE(1) |
| 2 1 | condr . Grain Sorghum/Cotton, Hidalgo Silty Clay Loam (Control Site) 96-97 | | TITLE(2) |
| 3 1 | Wea: 9 TX BROWNSVILLEWwi: 9 TX BROWNSVILLE W | | TITLE(3) |
| 4 1 | Number of years of simulation | 2 | NBYR |
| 4 2 | Starting date - Year | 1996 | IYR |
| 4 3 | Month | 1 | IMO |
| 4 4 | Day | 1 | IDA |
| 4 5 | Printout interval | 0 | NIPD |
| 4 6 | Output print code | 6 | IPD |
| 4 7 | Weather code | 12 | NGN |
| 4 8 | Number of times generator cycles | 0 | IGN |
| 4 9 | Day weather generator stops generating same weather | 0 | IGSD |
| 4 10 | Leap year considered | 0 | LPYR |
| 4 11 | Potential evaporation method code | 4 | IET |
| 4 12 | Curve number estimator (0 stochastic, >0 rigid) | 0 | ISCN |
| 4 13 | Graph Display (0 off, 1 on) | 1 | IGRAF |
| 4 14 | Output conversion code | 1 | ICODE |
| 4 15 | Peak rate estimate code | 0 | ITYP |
| 4 16 | Static soil code | 0 | ISTA |
| 4 17 | Automatic heat unit scheduling | 0 | IHUS |
| 4 18 | Number of cows | 0 | NCOW |
| 4 19 | Non-varying CN - CN2 used for all storms | 0 | NVCN |
| 4 20 | Runoff (Q) estimation methodology | 0 | INFL |
| 4 21 | Pesticide Output in Mass and/or Conc | 0 | MASP |
| 5 1 | Watershed drainage area (ha) | 6.07 | WSA |
| 5 2 | Runoff curve number | 70.0 | CN2 |
| 5 3 | Channel Length1 (Km) | .35 | CHL |
| 5 4 | Average channel slope (m/ m) | .0013 | CHS |
| 5 5 | Channel roughness factor(manning's N) | .0900 | CHN |
| 5 6 | Surface roughness factor(manning's N) | .0900 | SN |
| 5 7 | Peak runoff-rate rainfall energy adjustment factor | 1.0 | APM |
| 5 8 | Latitude of watershed (degrees) | 26.27 | YLT |
| 5 9 | Average elevation of watershed (m) | 7.0 | ELEV |
| 5 10 | Water content of snow on ground at start of simulation (mm) | 0 | SNO |
| 6 1 | Average concentration of nitrogen in rainfall (g m$^3$) [PPM] | .8 | RCN |
| 6 2 | Number of years of cultivation before simulation starts (yr ) | 50.0 | RTN |
| 6 3 | CO2 concentration in atmosphere [PPM] | 330.0 | C02 |
| 6 4 | NO3 concentration in irrigation water [PPM] | .1 | CN03I |
| 6 5 | CSALT salt concentration in irrigation water [PPM] | 960.0 | CSALT |
| 6 6 | CHD Channel depth [m] | .152 | CHD |
| 6 7 | Drainage Area of a watershed feeding a Lagoon (ha) | .000 | DALG |
| 6 8 | Normal Lagoon Volume (mm) | .000 | VLGN |
| 6 9 | Maximum Lagoon Volume (mm) | .000 | VLGM |
| 6 10 | Lagoon input from wash water (m$^3$/cow/day) | .000 | COWW |
| 7 1 | Slope length (m) | 348.4 | SL |
| 7 2 | Slope steepness (m /m) | .0013 | S |
| 7 3 | Erosion control practice | 1.00 | PEC |
| 7 4 | Water erosion equation | 3 | DRV |
| 7 5 | Parameter estimates for MUSI erosion equation | | BUS(1) |
| | | | BUS(2) |
| | | | BUS(3) |
| | | | BUS(4) |
| 8 3 | Number of years of max monthly 0.5 hour rainfall record | 8.0 | YWI |
| 8 4 | Coefficient used to establish wet-dry probability | .0 | BTA |
| 8 5 | Parameter used to modify exp rain distribution | .0 | EXPK |
| | | 100.0 | |
| | | 100.0 | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 1 | Average monthly maximum air temperature (°C) | 20.60 | 22.60 | 25.80 | 29.10 | 31.40 | 33.60 | 34.80 | 35.10 | 32.80 | 29.70 | 24.70 | 22.00 | OBMX(1-12) |
| 10 1 | Average monthly minimum air temperature (°C) | 9.30 | 10.80 | 14.10 | 18.00 | 21.00 | 22.80 | 23.30 | 23.20 | 21.80 | 17.90 | 13.30 | 10.60 | OBMN(1-12) |
| 11 1 | Monthly standard deviation maximum air temperature (°C) | 6.70 | 6.10 | 5.20 | 3.90 | 2.80 | 2.30 | 2.20 | 2.50 | 3.10 | 3.80 | 6.50 | 6.20 | SDTMX(1-12) |
| 12 1 | Monthly standard deviation minimum air temperature (°C) | 6.00 | 5.70 | 5.30 | 4.20 | 3.00 | 2.10 | 1.40 | 1.40 | 2.40 | 4.00 | 5.70 | 5.80 | SDTMN(1-12) |
| 13 1 | Average monthly precipitation (mm) | 35.2 | 41.6 | 22.5 | 48.3 | 68.7 | 73.6 | 41.1 | 71.5 | 129.7 | 67.9 | 39.1 | 32.7 | RMO(1-12) |
| 14 1 | Monthly standard deviation of daily precipitation (mm) | 7.9 | 16.0 | 8.5 | 27.2 | 19.5 | 16.2 | 12.6 | 17.4 | 21.0 | 14.9 | 10.7 | 8.5 | RST2(1-12) |
| 15 1 | Monthly skew coefficient for daily precipitation | 4.58 | 7.54 | 3.45 | 6.07 | 3.36 | 2.41 | 4.54 | 3.64 | 3.10 | 2.74 | 2.70 | 4.08 | RST3(1-12) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16.1 | Monthly probability of wet day after dry day | .171 | .145 | .107 | .103 | .132 | .130 | .117 | .138 | .221 | .148 | .142 | .151 | PRW1(1-12) |
| 17.1 | Monthly probability of wet day after wet day | .508 | .506 | .365 | .400 | .364 | .498 | .417 | .483 | .541 | .437 | .440 | .490 | PRW2(1-12) |
| 18.1 | Average number of days of rain per month | 8.00 | 6.40 | 4.50 | 4.40 | 5.30 | 6.20 | 5.20 | 6.50 | 9.70 | 6.40 | 6.10 | 7.10 | DAYP(1-12) |
| 19.1 | Monthly maximum 0.5 hour-rainfall for period of record (TP24) (mm) | 8.4 | 18.3 | 3.3 | 40.9 | 25.7 | 36.1 | 25.7 | 44.5 | 31.5 | 58.2 | 21.1 | 20.8 | WI(1-12) |
| 20.1 | Monthly average daily solar radiation (MJ/m$^2$ or ly) | 296. | 341. | 403. | 456 | 564. | 610 | 626. | 568. | 475. | 411. | 296. | 263. | OBSL(1-12) |
| 21.1 | Montly average relative humidity (fraction) | 76 | 75 | .72 | 72 | .74 | .73 | .72 | .71 | .73 | .73 | .76 | .75 | RH(1-12) |
| 22.1 | Field length (km) | | | | | | | | | | .35 | | | FL |
| 22.2 | Field width (km) | | | | | | | | | | .17 | | | FW |
| 22.3 | Clockwise angle of field from north (deg) | | | | | | | | | | 355.00 | | | ANG |
| 22.4 | Standing dead crop residue (t/ha) | | | | | | | | | | .00 | | | STD |
| 23.1 | Power of modified exponential distribution of wind speed | | | | | | | | | | .30 | | | UXP |
| 23.2 | Climate factor | | | | | | | | | | 350.00 | | | DIAM |
| | | | | | | | | | | | .00 | | | |
| 24.1 | Average monthly wind velocity (m/s) | 5.24 | 5.51 | 5.97 | 6.27 | 5.92 | 5.45 | 5.13 | 4.64 | 4.24 | 4.33 | 4.82 | 4.85 | UAVM(1-12) |
| 25.1 | N wind during each month (%) | 9.0 | 9.0 | 6.0 | 4.0 | 2.0 | 1.0 | .0 | 2.0 | 5.0 | 7.0 | 8.0 | 9.0 | DIR1(1-12) |
| 26.1 | NNE wind during each month (%) | 4.0 | 4.0 | 4.0 | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 4.0 | 4.0 | 4.0 | 3.0 | DIR2(1-12) |
| 27.1 | NE wind during each month (%) | 3.0 | 5.0 | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 3.0 | 8.0 | 7.0 | 4.0 | 3.0 | DIR3(1-12) |
| 28.1 | ENE wind during each month (%) | 2.0 | 4.0 | 5.0 | 4.0 | 4.0 | 3.0 | 1.0 | 4.0 | 7.0 | 5.0 | 3.0 | 3.0 | DIR4(1-12) |
| 29.1 | E wind during each month (%) | 3.0 | 5.0 | 7.0 | 8.0 | 7.0 | 7.0 | 5.0 | 8.0 | 9.0 | 8.0 | 4.0 | 3.0 | DIR5(1-12) |
| 30.1 | ESE wind during each month (%) | 5.0 | 7.0 | 10.0 | 13.0 | 16.0 | 16.0 | 12.0 | 14.0 | 13.0 | 11.0 | 6.0 | 5.0 | DIR6(1-12) |
| 31.1 | SE wind during each month (%) | 13.0 | 15.0 | 19.0 | 26.0 | 34.0 | 36.0 | 35.0 | 29.0 | 16.0 | 17.0 | 12.0 | 11.0 | DIR7(1-12) |
| 32.1 | SSE wind during each month (%) | 17.0 | 17.0 | 20.0 | 22.0 | 20.0 | 22.0 | 31.0 | 23.0 | 11.0 | 11.0 | 15.0 | 14.0 | DIR8(1-12) |
| 33.1 | S wind during each month (%) | 10.0 | 9.0 | 9.0 | 7.0 | 5.0 | 6.0 | 11.0 | 10.0 | 6.0 | 5.0 | 10.0 | 12.0 | DIR9(1-12) |
| 34.1 | SSW wind during each month (%) | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 2.0 | 3.0 | DIR10(1-12) |
| 35.1 | SW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR11(1-12) |
| 36.1 | WSW wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | 0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | DIR12(1-12) |
| 37.1 | W wind during each month (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | 1.0 | 1.0 | 2.0 | 2.0 | DIR13(1-12) |
| 38.1 | WNW wind during each month (%) | 3.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | DIR14(1-12) |
| 39.1 | NW wind during each month (%) | 10.0 | 8.0 | 4.0 | 2.0 | 2.0 | 1.0 | .0 | 2.0 | 8.0 | 8.0 | 11.0 | 11.0 | DIR15(1-12) |
| 40.1 | NNW wind during each month (%) | 15.0 | 10.0 | 6.0 | 3.0 | 2.0 | 1.0 | 0 | 2.0 | 7.0 | 9.0 | 13.0 | 15.0 | DIR16(1-12) |
| 41.1 | Soil albedo | | | | | | | | | | .02 | | | SALB |
| 41.2 | Maxium number of soil layers | | | | | | | | | | 10. | | | TSLA |
| 41.3 | Minimum thickness of maxium layer (m) | | | | | | | | | | .00 | | | ZQT |
| 41.4 | Initial layer splitting thickness (cm) | | | | | | | | | | | | | ZTK |
| 41.5 | Minimum soil profile thickness (cm) | | | | | | | | | | | | | ZF |
| 41.6 | Initial soil water content-fraction of field capacity | | | | | | | | | | .50 | | | FFC |
| 41.7 | Minimum depth to water table (m) | | | | | | | | | | 1.60 | | | WTMN |
| 41.8 | Maximum depth to water table (m) | | | | | | | | | | 4.57 | | | WTMX |
| 41.9 | Initial depth to water table (m) | | | | | | | | | | 4.27 | | | WTBL |
| 41.10 | Soil weathering code | | | | | | | | | | 0. | | | XIDS |
| 41.11 | Time for sub surface flow travel time(d) | | | | | | | | | | 0. | | | RFTT |
| 42.1 | Depth from the surface to the bottom of the soil layer (m) | .010 | .360 | .940 | 1.980 | | | | | | | | | Z(1-10) |
| 43.1 | Bulk density of the soil layer (t/m$^3$) | 1.340 | 1.340 | 1.490 | 1.510 | | | | | | | | | BD(1-10) |
| 44.1 | Wilting point (1500 kPa) (m/m) | .230 | .230 | .250 | .250 | | | | | | | | | U(1-10) |
| 45.1 | Field capacity (33kPa) (m/m) | .410 | .410 | .410 | .390 | | | | | | | | | FC(1-10) |
| 46.1 | Sand content (%) | 30.4 | 30.4 | 29.2 | 29.2 | | | | | | | | | SAN(1-10) |
| 47.1 | Silt content (%) | 32.6 | 32.6 | 31.3 | 31.3 | | | | | | | | | SIL(1-10) |
| 48.1 | Organic N concentration (g/t) [PPM] | | 506. | 501. | 422. | | | | | | | | | WN(1-10) |
| 49.1 | Soil pH | 8.2 | 8.2 | 8.2 | 8.2 | | | | | | | | | PH(1-10) |
| 50.1 | Sum of bases (cmol/kg) | | | | | | | | | | | | | SMB(1-10) |
| 51.1 | Organic carbon (%) | .68 | .39 | .39 | .32 | | | | | | | | | CBN(1-10) |
| 52.1 | Calcium carbonate (%) | | | | | | | | | | | | | CAC(1-10) |
| 53.1 | Cation exchange capacity (cmol/kg) | | | | | | | | | | | | | CEC(1-10) |
| 54.1 | Coarse fragment content (% vol) | | 1.3 | 4.0 | | | | | | | | | | ROK(1-10) |
| 55.1 | Initial Nitrate concentration (g/t$^1$) [PPM] | 1. | 7. | 14. | 12. | | | | | | | | | WNO3(1-10) |
| 56.1 | Labile P concentration (g/t$^3$) [PPM] | 211. | 200. | | | | | | | | | | | O(1-10) |
| 57.1 | Crop residue (t/ha) | | | | | | | | | | | | | RSD(1-10) |
| 58.1 | Bulk density (oven dry) (t/m$^3$) | 1.57 | 1.57 | 1.72 | 1.74 | | | | | | | | | BDD(1-10) |
| 59.1 | Phosphorus sorption ratio | | | | | | | | | | | | | PSP(1-10) |
| 60.1 | Saturated conductivity (mm/h) | 2.81 | 2.81 | 1.28 | 1.15 | | | | | | | | | SC(1-10) |
| 61.1 | Fraction of storage interacting with NO3 leaching | | | | | | | | | | | | | STFR(1-10) |
| 62.1 | Organic P concentration (g/t) [PPM] | | 103 | 103. | 93. | | | | | | | | | WP(1-10) |
| 63.1 | Crop rotation duration (yr.) | | | | | | | | | | 2 | | | NRO |
| 63.2 | Rigid or variable irrigation | | | | | | | | | | 1 | | | NIRR |
| 63.3 | Irrigation code | | | | | | | | | | 0 | | | IRR |
| 63.4 | Minimum application interval for automatic irrigation (d) | | | | | | | | | | 0 | | | IRI |
| 63.5 | Minimum fertilizer application interval for automatic fertilizer (d) | | | | | | | | | | 0 | | | IFA |

| | | | |
|---|---|---|---|
| 63.6 | Liming code | 1 | LM |
| 63.7 | Furrow dike code | 0 | IFD |
| 63.8 | Drainage code | 0 | IDR |
| 63.9 | Automatic fertilizer or fertigation fertilizer file | 0 | IDFT |
| 64.1 | Water stress factor to trigger automatic irrigation | .00 | BIR |
| 64.2 | Irrigation runoff ratio | .00 | EFI |
| 64.3 | Maximum annual irrigation volume allowed for each crop (mm) | .00 | VIMX |
| 64.4 | Minimum single application volume automatic irrigation (mm) | .00 | ARMN |
| 64.5 | Maximum single application volume automatic irrigation (mm) | .00 | ARMX |
| 64.6 | N stress factor to trigger automatic fertilizer | .00 | BFT |
| 64.7 | Amount of fertilizer (IDFT) per automatically scheduled application | .00 | FNP |
| 64.8 | Maxium annual N fertilizer application for a crop (kg/ha) | 99999.0 | FMX |
| 64.9 | Time required for drainage system to reduce stress (d) | .00 | DRT |
| 64.10 | Fraction of furrow dike volume available for storage | .00 | FDSF |

## .3 Management Information-Irrigation Fertilizer/Tillage Schedule
## One line for each operation and one section for each year of rotation)

| MON | DAY | COD | CRP/GRZ | MAT | PHU | CND | WSF | | FPP | FNMX | HUSC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FN | | FAP | FDP | | | | | |
| | | | | | LA | | | QVOL | | | |
| | | | PST | | PCF | PAR | | | | | |
| | 26 | 15 | | | | | | | | | |
| | 27 | 80 | | | | | | | | | |
| | 1 | 71 | 67 | 280.00 | 85.00 | | | | | | |
| | 1 | 19 | | | | | | | | | |
| | 13 | 2 | 3 | 2000.00 | | | | | | | |
| | 15 | 11 | 3 | 90 | 80 | | | | | | |
| | 1 | 19 | | | | | | | | | |
| | 15 | 51 | | | | | | | | | |
| | 20 | 32 | | | | | | | | | |
| | 1 | 11 | 204 | 90 | 1.10 | | | | | | |
| | 19 | 41 | | | | | | | | | |
| | 20 | 16 | | | | | | | | | |
| | 30 | 15 | | | | | | | | | |
| | | | | | | | | | | | |
| | 19 | 19 | | | | | | | | | |
| | 19 | 80 | | | | | | | | | |
| | 18 | 71 | 67 | 402.50 | 85.0 | | | | | | |
| | 23 | 2 | 5 | 2900.00 | | | | | | | |
| | 5 | 19 | | | | | | | | | |
| | 1 | 11 | 96 | 1.00 | 20 | | | | | | |
| | 15 | 51 | | | | | | | | | |
| | 16 | 41 | | | | | | | | | |
| | 17 | 57 | | | | | | | | | |
| | 18 | 15 | | | | | | | | | |
| | 15 | 23 | | | | | | | | | |
| | 15 | 23 | | | | | | | | | |

MON = Month of the operation
DAY = Day of the operation
COD = Operation/Tillage code number
CRP/GRZ = Crop identification number OR Grazing
MAT = Years necessary to mature or year until harvest. (For trees only)
PHU = Potential Heat Units
CND = Runoff curve number after this operation
WSF = Plant water stress factor
FPP = Fraction of original plant population
FNMX = Maximum annual nitrogen fertilizer applied to a crop
HUSC = Time of this operation as a fraction of the growing season or of the year if no crop is growing; using 0°C as the base temperature
FN = Fertilizer ID number applied
FAP = Fertilizer application rate (Kg/ha-0% moisture)
FDP = Depth of fertilizer placement (mm)
IA = Irrigation volume (mm)
QVOL = Runoff VOL/VOL of irrigation water applied
PST = Pesticide ID number
PCF = Pest control factor (fraction)
PAR = Pesticide application rate (Kg/ha or lbs/ac of active ingredient)

# APPENDIX G

## Results of EPIC Sensitivity Analysis

### PIC Variable DRT, Days Required for Drainage to Reduce Plant Stress

| DRT days | PRCP mm | Q mm | SSF mm | PRK mm | QDRN mm | IRGA mm | ET mm | YON kg/ha | YNO3 kg/ha | SSFN kg/ha | PRKN kg/ha | DRNN kg/ha | FNO3 kg/ha | FNH3 kg/ha | YP kg/ha | YAP kg/ha | PRKP kg/ha | MUSS t/ha | YW t/ha | UNO3 kg/ha | UPP kg/ha | DN kg/ha | GRSG t/ha | COTP t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 762.80 | 193.85 | 227.11 | 1.10 | 223.39 | 320.04 | 740.33 | 13.96 | 3.88 | 27.25 | 0.12 | 25.61 | 28.32 | 84.00 | 3.38 | 0.03 | 0.00 | 15.50 | 5.52 | 381.93 | 62.31 | 16.90 | 5.51 | 2.33 |
| 0.5 | 762.80 | 193.86 | 225.28 | 2.72 | 222.04 | 320.04 | 740.47 | 13.96 | 3.88 | 27.03 | 0.30 | 25.47 | 28.32 | 84.00 | 3.38 | 0.03 | 0.01 | 15.51 | 5.52 | 381.87 | 62.29 | 16.91 | 5.51 | 2.33 |
| 1 | 762.80 | 193.90 | 222.21 | 5.39 | 219.83 | 320.04 | 740.79 | 13.95 | 3.88 | 26.66 | 0.59 | 25.25 | 28.32 | 84.00 | 3.38 | 0.03 | 0.01 | 15.51 | 5.50 | 381.74 | 62.25 | 16.92 | 5.51 | 2.33 |
| 1.5 | 762.80 | 193.92 | 219.27 | 8.00 | 217.44 | 320.04 | 741.05 | 13.97 | 3.88 | 26.31 | 0.96 | 25.01 | 28.32 | 84.00 | 3.38 | 0.03 | 0.02 | 15.52 | 5.52 | 381.62 | 62.22 | 16.94 | 5.50 | 2.33 |
| 2 | 762.80 | 193.94 | 216.53 | 10.55 | 215.04 | 320.04 | 741.18 | 14.00 | 3.88 | 25.98 | 1.27 | 24.77 | 28.32 | 84.00 | 3.39 | 0.03 | 0.03 | 15.52 | 5.58 | 381.47 | 62.17 | 16.95 | 5.50 | 2.33 |
| 2.5 | 762.80 | 193.96 | 213.91 | 13.05 | 212.67 | 320.04 | 741.22 | 14.09 | 3.88 | 25.67 | 1.57 | 24.54 | 28.32 | 84.00 | 3.41 | 0.03 | 0.03 | 15.52 | 5.72 | 381.28 | 62.13 | 16.96 | 5.50 | 2.33 |
| 3 | 762.80 | 193.97 | 211.40 | 15.48 | 210.33 | 320.04 | 741.22 | 14.20 | 3.88 | 25.37 | 1.86 | 24.31 | 28.32 | 84.00 | 3.44 | 0.03 | 0.04 | 15.53 | 5.89 | 381.10 | 62.08 | 16.97 | 5.49 | 2.32 |
| 3.5 | 762.80 | 193.99 | 208.97 | 17.87 | 208.03 | 320.04 | 741.17 | 14.27 | 3.88 | 25.08 | 2.14 | 24.09 | 28.32 | 84.00 | 3.46 | 0.03 | 0.05 | 15.53 | 5.99 | 380.90 | 62.04 | 16.98 | 5.49 | 2.32 |
| 4 | 762.80 | 194.00 | 206.61 | 20.20 | 205.78 | 320.04 | 741.11 | 14.32 | 3.88 | 24.79 | 2.42 | 23.87 | 28.32 | 84.00 | 3.47 | 0.03 | 0.05 | 15.53 | 6.07 | 380.69 | 61.99 | 16.99 | 5.49 | 2.32 |
| 4.5 | 762.80 | 194.01 | 204.32 | 22.48 | 203.57 | 320.04 | 741.02 | 14.31 | 3.88 | 24.52 | 2.70 | 23.65 | 28.32 | 84.00 | 3.47 | 0.03 | 0.06 | 15.54 | 6.05 | 380.48 | 61.94 | 17.01 | 5.48 | 2.32 |
| 5 | 762.80 | 194.02 | 202.08 | 24.71 | 201.40 | 320.04 | 740.91 | 14.30 | 3.88 | 24.25 | 2.97 | 23.43 | 28.32 | 84.00 | 3.46 | 0.03 | 0.06 | 15.54 | 6.04 | 380.25 | 61.89 | 17.02 | 5.48 | 2.32 |
| 5.5 | 762.80 | 194.04 | 199.90 | 26.89 | 199.27 | 320.04 | 740.80 | 14.30 | 3.88 | 23.99 | 3.23 | 23.22 | 28.32 | 84.00 | 3.46 | 0.03 | 0.07 | 15.54 | 6.03 | 380.03 | 61.84 | 17.03 | 5.48 | 2.32 |
| 6 | 762.80 | 194.05 | 197.77 | 29.03 | 197.19 | 320.04 | 740.68 | 14.29 | 3.88 | 23.73 | 3.48 | 23.01 | 28.32 | 84.00 | 3.46 | 0.03 | 0.08 | 15.55 | 6.02 | 379.80 | 61.79 | 17.05 | 5.47 | 2.31 |
| 6.5 | 762.80 | 194.06 | 195.69 | 31.13 | 195.15 | 320.04 | 740.56 | 14.29 | 3.88 | 23.48 | 3.74 | 22.81 | 28.32 | 84.00 | 3.46 | 0.03 | 0.08 | 15.55 | 6.01 | 379.58 | 61.74 | 17.06 | 5.47 | 2.31 |
| 7 | 762.80 | 194.07 | 193.66 | 33.18 | 193.15 | 320.04 | 740.43 | 14.29 | 3.88 | 23.24 | 3.98 | 22.61 | 28.32 | 84.00 | 3.46 | 0.03 | 0.09 | 15.55 | 6.01 | 379.35 | 61.69 | 17.07 | 5.47 | 2.31 |
| 7.5 | 762.80 | 194.08 | 191.67 | 35.19 | 191.19 | 320.04 | 740.29 | 14.29 | 3.88 | 23.00 | 4.22 | 22.41 | 28.32 | 84.00 | 3.46 | 0.03 | 0.09 | 15.55 | 6.01 | 379.14 | 61.64 | 17.09 | 5.46 | 2.31 |
| 8 | 762.80 | 194.09 | 189.72 | 37.16 | 189.28 | 320.04 | 740.16 | 14.29 | 3.88 | 22.77 | 4.46 | 22.21 | 28.32 | 84.00 | 3.46 | 0.03 | 0.10 | 15.56 | 6.00 | 378.91 | 61.60 | 17.10 | 5.46 | 2.31 |
| 8.5 | 762.80 | 194.10 | 187.81 | 39.09 | 187.39 | 320.04 | 740.02 | 14.29 | 3.88 | 22.54 | 4.69 | 22.02 | 28.32 | 84.00 | 3.46 | 0.03 | 0.10 | 15.56 | 6.00 | 378.70 | 61.55 | 17.11 | 5.46 | 2.30 |
| 9 | 762.80 | 194.11 | 185.94 | 40.98 | 185.55 | 320.04 | 739.89 | 14.30 | 3.88 | 22.31 | 4.92 | 21.83 | 28.32 | 84.00 | 3.46 | 0.03 | 0.11 | 15.56 | 6.00 | 378.47 | 61.50 | 17.12 | 5.45 | 2.30 |

Description of Variables:

| | |
|---|---|
| CN2 | Runoff curve number, antecedent moisture condition 2 |
| COTP | Crop yield for picker cotton (t/ha) |
| DN | N loss by denitrification (kg/ha) |
| DRNN | Mineral N loss in subsurface drain flow (kg/ha) |
| DRT | Drain time, days required for drainage to reduce plant stress (days) |
| ET | Evapotranspiration (mm) |
| FNH3 | Fertilizer N applied in the form $NH_3$-N (kg/ha) |
| FNO3 | Fertilizer N applied in the form $NO_3$-N (kg/ha) |
| GRSG | Crop yield for grain sorghum (t/ha) |
| IRGA | Irrigation water applied (mm) |
| MUSS | Soil loss from water erosion using a modified MUSLE option for small watersheds |
| PRCP | Precipitation (mm) |
| PRK | Percolation below the root zone (mm) |
| PRKN | Mineral N loss in percolate (kg/ha) |
| PRKP | Percolation of P below the root zone (kg/ha) |
| Q | Runoff (mm) |
| QDRN | Subsurface drain flow (mm) |
| SSF | Lateral subsurface flow (mm) |
| SSFN | Mineral N loss in subsurface flow (kg/ha) |
| UNO3 | N uptake by the crop (kg/ha) |
| UPP | P uptake by the crop (kg/ha) |
| WNO3 | Initial nitrate concentration in the soil (ppm) |
| YAP | Soluble P loss in runoff (kg/ha) |
| YNO3 | NO3 loss in surface runoff (kg/ha) |
| YON | Organic N loss with sediment (kg/ha) |
| YP | P loss with sediment (kg/ha) |
| YW | Soil loss from wind erosion (t/ha) |

# EPIC Variable DRT, Days Required for Drainage to Reduce Plant Stress
## % Change

| DRT | PRCP | Q | SSF | PRK | QDRN | IRGA | ET | YON | YNO3 | SSFN | PRKN | DRNN | FNO3 | FNH3 | YP | YAP | PRKP | MUSS | YW | UNO3 | UPP | DN | GRSG | COTP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -94% | 0.0% | -0.1% | 8.7% | -93.9% | 7.4% | 0.0% | -0.1% | -2.2% | -0.1% | 8.7% | -94.4% | 6.3% | 0.0% | 0.0% | -2.2% | -0.1% | -93.8% | -0.2% | -7.9% | 0.3% | 0.4% | -0.5% | 0.4% | 0.3% |
| -86% | 0.0% | -0.1% | 7.8% | -84.8% | 6.7% | 0.0% | -0.1% | -2.2% | -0.1% | 7.8% | -86.0% | 5.7% | 0.0% | 0.0% | -2.2% | -0.1% | -84.8% | -0.2% | -7.9% | 0.3% | 0.4% | -0.4% | 0.4% | 0.3% |
| -71% | 0.0% | 0.0% | 6.3% | -69.8% | 5.7% | 0.0% | -0.1% | -2.2% | 0.0% | 6.3% | -72.3% | 4.8% | 0.0% | 0.0% | -2.2% | 0.0% | -69.9% | -0.1% | -8.2% | 0.2% | 0.4% | -0.3% | 0.3% | 0.2% |
| -57% | 0.0% | 0.0% | 4.9% | -55.2% | 4.5% | 0.0% | 0.0% | -2.1% | 0.0% | 4.9% | -55.2% | 3.8% | 0.0% | 0.0% | -2.1% | 0.0% | -55.1% | -0.1% | -7.9% | 0.2% | 0.3% | -0.2% | 0.2% | 0.2% |
| -43% | 0.0% | 0.0% | 3.6% | -40.9% | 3.4% | 0.0% | 0.0% | -1.8% | 0.0% | 3.6% | -40.9% | 2.8% | 0.0% | 0.0% | -1.9% | 0.0% | -41.0% | -0.1% | -6.9% | 0.1% | 0.2% | -0.2% | 0.2% | 0.2% |
| -29% | 0.0% | 0.0% | 2.4% | -27.0% | 2.2% | 0.0% | 0.0% | -1.2% | 0.0% | 2.4% | -27.0% | 1.9% | 0.0% | 0.0% | -1.2% | 0.0% | -26.9% | 0.0% | -4.6% | 0.1% | 0.1% | -0.1% | 0.1% | 0.1% |
| -14% | 0.0% | 0.0% | 1.2% | -13.3% | 1.1% | 0.0% | 0.0% | -0.4% | 0.0% | 1.2% | -13.3% | 0.9% | 0.0% | 0.0% | -0.5% | 0.0% | -13.5% | 0.0% | -1.7% | 0.1% | 0.1% | 0.0% | 0.1% | 0.1% |
| 0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 14% | 0.0% | 0.0% | -1.1% | 13.0% | -1.1% | 0.0% | 0.0% | 0.4% | 0.0% | -1.1% | 13.0% | -0.9% | 0.0% | 0.0% | 0.4% | 0.0% | 13.0% | 0.0% | 1.4% | -0.1% | -0.1% | 0.1% | -0.1% | -0.1% |
| 29% | 0.0% | 0.0% | -2.2% | 25.8% | -2.1% | 0.0% | 0.0% | 0.3% | 0.0% | -2.2% | 25.8% | -1.8% | 0.0% | 0.0% | 0.3% | 0.0% | 25.6% | 0.0% | 1.0% | -0.1% | -0.2% | 0.2% | -0.1% | -0.1% |
| 43% | 0.0% | 0.0% | -3.3% | 38.3% | -3.2% | 0.0% | 0.0% | 0.2% | 0.0% | -3.3% | 38.3% | -2.7% | 0.0% | 0.0% | 0.2% | 0.0% | 38.2% | 0.1% | 0.8% | -0.2% | -0.2% | 0.3% | -0.2% | -0.2% |
| 57% | 0.0% | 0.0% | -4.3% | 50.5% | -4.2% | 0.0% | -0.1% | 0.2% | 0.0% | -4.3% | 50.5% | -3.6% | 0.0% | 0.0% | 0.2% | 0.0% | 50.4% | 0.1% | 0.6% | -0.2% | -0.3% | 0.3% | -0.2% | -0.3% |
| 71% | 0.0% | 0.0% | -5.4% | 62.5% | -5.2% | 0.0% | -0.1% | 0.2% | 0.0% | -5.4% | 62.5% | -4.5% | 0.0% | 0.0% | 0.2% | 0.0% | 62.4% | 0.1% | 0.5% | -0.3% | -0.4% | 0.4% | -0.3% | -0.4% |
| 86% | 0.0% | 0.0% | -6.4% | 74.2% | -6.2% | 0.0% | -0.1% | 0.2% | 0.0% | -6.4% | 74.2% | -5.3% | 0.0% | 0.0% | 0.1% | 0.0% | 74.1% | 0.1% | 0.4% | -0.3% | -0.5% | 0.5% | -0.4% | -0.4% |
| 100% | 0.0% | 0.0% | -7.3% | 85.7% | -7.2% | 0.0% | -0.1% | 0.2% | 0.0% | -7.3% | 85.7% | -6.2% | 0.0% | 0.0% | 0.1% | 0.0% | 85.5% | 0.1% | 0.3% | -0.4% | -0.6% | 0.6% | -0.4% | -0.5% |
| 114% | 0.0% | 0.0% | -8.3% | 96.9% | -8.1% | 0.0% | -0.1% | 0.2% | 0.0% | -8.3% | 96.9% | -7.0% | 0.0% | 0.0% | 0.1% | 0.0% | 96.8% | 0.2% | 0.2% | -0.5% | -0.6% | 0.6% | -0.5% | -0.6% |
| 129% | 0.0% | 0.1% | -9.2% | 108.0% | -9.0% | 0.0% | -0.1% | 0.2% | 0.1% | -9.2% | 108.0% | -7.8% | 0.0% | 0.0% | 0.1% | 0.1% | 107.7% | 0.2% | 0.2% | -0.5% | -0.7% | 0.7% | -0.5% | -0.7% |
| 143% | 0.0% | 0.1% | -10.1% | 118.8% | -9.9% | 0.0% | -0.2% | 0.2% | 0.1% | -10.1% | 118.8% | -8.6% | 0.0% | 0.0% | 0.1% | 0.1% | 118.6% | 0.2% | 0.2% | -0.6% | -0.8% | 0.8% | -0.6% | -0.8% |
| 157% | 0.0% | 0.1% | -11.0% | 129.3% | -10.8% | 0.0% | -0.2% | 0.2% | 0.1% | -11.0% | 129.3% | -9.4% | 0.0% | 0.0% | 0.1% | 0.1% | 129.1% | 0.2% | 0.2% | -0.6% | -0.9% | 0.8% | -0.6% | -0.8% |

## PIC Variable WNO3, Initial Nitrate Concentration (ppm) in Soil Layers 1 - 3

| WNO3 ppm | PRCP mm | Q mm | SSF mm | PRK mm | QDRN mm | IRGA mm | ET mm | YON kg/ha | YNO3 kg/ha | SSFN kg/ha | PRKN kg/ha | DRNN kg/ha | FNO3 kg/ha | FNH3 kg/ha | YP kg/ha | YAP kg/ha | PRKP kg/ha | MUSS t/ha | YW t/ha | UNO3 kg/ha | UPP kg/ha | DN kg/ha | GRSG t/ha | COTP t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 762.80 | 193.98 | 208.96 | 17.87 | 208.02 | 320.04 | 741.13 | 12.98 | 3.88 | 14.63 | 1.25 | 14.65 | 28.32 | 84.00 | 3.14 | 0.03 | 0.05 | 14.06 | 5.69 | 321.83 | 60.41 | 10.61 | 5.08 | 2.32 |
| 2 | 762.80 | 193.98 | 208.96 | 17.87 | 208.02 | 320.04 | 741.15 | 13.37 | 3.88 | 16.72 | 1.43 | 16.85 | 28.32 | 84.00 | 3.24 | 0.03 | 0.05 | 14.53 | 5.79 | 336.12 | 61.23 | 12.06 | 5.27 | 2.32 |
| 3 | 762.80 | 193.98 | 208.96 | 17.87 | 208.02 | 320.04 | 741.16 | 13.68 | 3.88 | 18.81 | 1.61 | 19.12 | 28.32 | 84.00 | 3.32 | 0.03 | 0.05 | 14.88 | 5.87 | 350.60 | 61.69 | 13.57 | 5.39 | 2.32 |
| 4 | 762.80 | 193.99 | 208.97 | 17.87 | 208.03 | 320.04 | 741.17 | 14.05 | 3.88 | 20.90 | 1.79 | 21.52 | 28.32 | 84.00 | 3.41 | 0.03 | 0.05 | 15.30 | 5.95 | 365.61 | 61.91 | 15.21 | 5.45 | 2.32 |
| 5 | 762.80 | 193.99 | 208.97 | 17.87 | 208.03 | 320.04 | 741.17 | 14.27 | 3.88 | 25.08 | 2.14 | 24.09 | 28.32 | 84.00 | 3.46 | 0.03 | 0.05 | 15.53 | 5.99 | 380.90 | 62.04 | 16.98 | 5.49 | 2.32 |
| 6 | 762.80 | 193.99 | 208.94 | 17.86 | 208.01 | 320.04 | 741.21 | 14.38 | 3.88 | 27.16 | 2.32 | 26.65 | 28.32 | 84.00 | 3.48 | 0.03 | 0.05 | 15.61 | 6.01 | 391.65 | 62.10 | 18.75 | 5.51 | 2.32 |
| 7 | 762.80 | 193.98 | 208.75 | 17.85 | 207.81 | 320.04 | 741.43 | 14.44 | 3.88 | 29.22 | 2.50 | 29.14 | 28.32 | 84.00 | 3.48 | 0.04 | 0.05 | 15.62 | 6.02 | 399.19 | 62.13 | 20.51 | 5.52 | 2.32 |
| 8 | 762.80 | 193.97 | 208.63 | 17.84 | 207.69 | 320.04 | 741.56 | 14.50 | 5.82 | 31.29 | 2.68 | 31.77 | 28.32 | 84.00 | 3.49 | 0.04 | 0.05 | 15.63 | 6.02 | 407.08 | 62.56 | 22.31 | 5.53 | 2.32 |
| 9 | 762.80 | 193.97 | 208.58 | 17.83 | 207.64 | 320.04 | 741.62 | 14.57 | 5.82 | 35.46 | 3.03 | 34.51 | 28.32 | 84.00 | 3.50 | 0.04 | 0.05 | 15.66 | 6.03 | 415.13 | 62.94 | 24.13 | 5.53 | 2.32 |
| 10 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.63 | 14.66 | 5.82 | 37.54 | 3.21 | 37.19 | 28.32 | 84.00 | 3.51 | 0.04 | 0.05 | 15.69 | 6.04 | 423.19 | 63.05 | 26.02 | 5.53 | 2.32 |
| 11 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.74 | 5.82 | 39.63 | 3.39 | 39.87 | 28.32 | 84.00 | 3.52 | 0.04 | 0.05 | 15.73 | 6.04 | 431.24 | 63.05 | 27.89 | 5.53 | 2.32 |
| 12 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.81 | 5.82 | 43.80 | 3.57 | 42.56 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.75 | 6.05 | 439.30 | 63.05 | 29.76 | 5.53 | 2.32 |
| 13 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.88 | 5.82 | 45.89 | 3.92 | 45.25 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 447.36 | 63.05 | 31.63 | 5.53 | 2.32 |
| 14 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 50.06 | 4.28 | 50.32 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 449.48 | 63.05 | 32.88 | 5.53 | 2.32 |
| 15 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 56.31 | 4.81 | 56.25 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 449.48 | 63.05 | 33.91 | 5.53 | 2.32 |
| 16 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 62.57 | 5.35 | 62.17 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 449.48 | 63.05 | 34.95 | 5.53 | 2.32 |
| 17 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 68.83 | 5.88 | 68.08 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 449.48 | 63.05 | 35.98 | 5.53 | 2.32 |
| 18 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 75.08 | 6.42 | 74.01 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.05 | 449.48 | 63.05 | 37.01 | 5.53 | 2.32 |
| 19 | 762.80 | 193.97 | 208.57 | 17.83 | 207.63 | 320.04 | 741.64 | 14.90 | 5.82 | 79.26 | 6.95 | 79.94 | 28.32 | 84.00 | 3.53 | 0.04 | 0.05 | 15.78 | 6.06 | 449.48 | 63.05 | 38.04 | 5.53 | 2.32 |

Description of Variables:

| | |
|---|---|
| CN2 | Runoff curve number, antecedent moisture condition 2 |
| COTP | Crop yield for picker cotton (t/ha) |
| DN | N loss by denitrification (kg/ha) |
| DRNN | Mineral N loss in subsurface drain flow (kg/ha) |
| DRT | Drain time, days required for drainage to reduce plant stress (days) |
| ET | Evapotranspiration (mm) |
| FNH3 | Fertilizer N applied in the form $NH_3$-N (kg/ha) |
| FNO3 | Fertilizer N applied in the form $NO_3$-N (kg/ha) |
| GRSG | Crop yield for grain sorghum (t/ha) |
| IRGA | Irrigation water applied (mm) |
| MUSS | Soil loss from water erosion using a modified MUSLE option for small watersheds |
| PRCP | Precipitation (mm) |
| PRK | Percolation below the root zone (mm) |
| PRKN | Mineral N loss in percolate (kg/ha) |
| PRKP | Percolation of P below the root zone (kg/ha) |
| Q | Runoff (mm) |
| QDRN | Subsurface drain flow (mm) |
| SSF | Lateral subsurface flow (mm) |
| SSFN | Mineral N loss in subsurface flow (kg/ha) |
| UNO3 | N uptake by the crop (kg/ha) |
| UPP | P uptake by the crop (kg/ha) |
| WNO3 | Initial nitrate concentration in the soil (ppm) |
| YAP | Soluble P loss in runoff (kg/ha) |
| YNO3 | NO3 loss in surface runoff (kg/ha) |
| YON | Organic N loss with sediment (kg/ha) |
| YP | P loss with sediment (kg/ha) |
| YW | Soil loss from wind erosion (t/ha) |

## EPIC Variable WNO3, Initial Nitrate Concentration (ppm) in Soil Layers 1 - 3
## % Change

| WNO3 | PRCP | Q | SSF | PRK | QDRN | IRGA | ET | YON | YNO3 | SSFN | PRKN | DRNN | FNO3 | FNH3 | YP | YAP | PRKP | MUSS | YW | UNO3 | UPP | DN | GRSG | COTP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -88% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | -0.1% | -10.5% | -33.3% | -53.3% | -53.3% | -53.9% | 0.0% | 0.0% | -10.1% | -16.5% | 0.2% | -10.1% | -5.5% | -20.9% | -3.4% | -52.4% | -8.1% | 0.0% |
| -75% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | -0.1% | -7.8% | -33.3% | -46.6% | -46.6% | -47.0% | 0.0% | 0.0% | -7.1% | -11.0% | 0.2% | -7.1% | -3.9% | -17.4% | -2.1% | -45.9% | -4.6% | 0.0% |
| -63% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | -0.1% | -5.7% | -33.3% | -39.9% | -39.9% | -39.8% | 0.0% | 0.0% | -4.9% | -5.5% | 0.2% | -4.8% | -2.6% | -13.9% | -1.4% | -39.1% | -2.5% | 0.0% |
| -50% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | -0.1% | -3.1% | -33.3% | -33.2% | -33.2% | -32.2% | 0.0% | 0.0% | -2.4% | -5.5% | 0.2% | -2.1% | -1.3% | -10.2% | -1.0% | -31.8% | -1.3% | 0.0% |
| -38% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | -0.1% | -1.6% | -33.3% | -19.9% | -19.9% | -24.2% | 0.0% | 0.0% | -1.0% | -5.5% | 0.2% | -0.6% | -0.5% | -6.4% | -0.8% | -23.9% | -0.7% | 0.0% |
| -25% | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.0% | 0.0% | -0.9% | -33.3% | -13.2% | -13.2% | -16.1% | 0.0% | 0.0% | -0.5% | -5.5% | 0.2% | -0.1% | -0.3% | -3.8% | -0.7% | -15.9% | -0.3% | 0.0% |
| -13% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | -0.4% | -33.3% | -6.6% | -6.6% | -8.3% | 0.0% | 0.0% | -0.3% | 0.0% | 0.0% | -0.1% | -0.1% | -1.9% | -0.7% | -8.1% | 0.0% | 0.0% |
| 0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 13% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.5% | 0.0% | 13.3% | 13.3% | 8.6% | 0.0% | 0.0% | 0.3% | 5.5% | 0.2% | 0.2% | 0.1% | 2.0% | 0.6% | 8.2% | 0.0% | 0.0% |
| 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1.1% | 0.0% | 20.0% | 20.0% | 17.1% | 0.0% | 0.0% | 0.6% | 5.5% | 0.2% | 0.4% | 0.2% | 4.0% | 0.8% | 16.6% | 0.0% | 0.0% |
| 38% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1.6% | 0.0% | 26.6% | 26.6% | 25.5% | 0.0% | 0.0% | 0.8% | 5.5% | 0.2% | 0.6% | 0.3% | 5.9% | 0.8% | 25.0% | 0.0% | 0.0% |
| 50% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.1% | 0.0% | 40.0% | 33.3% | 34.0% | 0.0% | 0.0% | 1.0% | 5.5% | 0.2% | 0.8% | 0.4% | 7.9% | 0.8% | 33.4% | 0.0% | 0.0% |
| 63% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.6% | 0.0% | 46.6% | 46.6% | 42.4% | 0.0% | 0.0% | 1.1% | 5.5% | 0.2% | 0.9% | 0.5% | 9.9% | 0.8% | 41.8% | 0.0% | 0.0% |
| 75% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 60.0% | 60.0% | 58.4% | 0.0% | 0.0% | 1.1% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 47.4% | 0.0% | 0.0% |
| 88% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 79.9% | 79.9% | 77.1% | 0.0% | 0.0% | 1.2% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 52.0% | 0.0% | 0.0% |
| 100% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 99.9% | 99.9% | 95.7% | 0.0% | 0.0% | 1.2% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 56.7% | 0.0% | 0.0% |
| 113% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 119.9% | 119.9% | 114.3% | 0.0% | 0.0% | 1.2% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 61.3% | 0.0% | 0.0% |
| 125% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 139.9% | 139.9% | 133.0% | 0.0% | 0.0% | 1.2% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 65.9% | 0.0% | 0.0% |
| 138% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.7% | 0.0% | 153.3% | 159.9% | 151.6% | 0.0% | 0.0% | 1.2% | 5.5% | 0.2% | 1.0% | 0.5% | 10.4% | 0.8% | 70.5% | 0.0% | 0.0% |

# EPIC Variable CN2, Runoff Curve Number - Antecedent Moisture Condition 2

| CN2 | PRCP mm | Q mm | SSF mm | PRK mm | QDRN mm | IRGA mm | ET mm | YON Kg/ha | YNO3 Kg/ha | SSFN Kg/ha | PRKN Kg/ha | DRNN Kg/ha | FNO3 Kg/ha | FNH3 Kg/ha | YP Kg/ha | YAP Kg/ha | PRKP Kg/ha | MUSS t/ha | YW t/ha | UNO3 Kg/ha | UPP Kg/ha | DN Kg/ha | GRSG t/ha | COTP t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74 | 762.80 | 131.41 | 244.51 | 20.90 | 243.35 | 320.04 | 758.59 | 10.10 | 1.31 | 29.34 | 2.51 | 30.09 | 28.32 | 84.00 | 2.43 | 0.02 | 0.05 | 9.83 | 5.05 | 371.75 | 60.75 | 17.19 | 5.49 | 2.21 |
| 75 | 762.80 | 128.90 | 246.58 | 21.08 | 245.40 | 320.04 | 759.03 | 10.06 | 1.29 | 29.59 | 2.53 | 30.42 | 28.32 | 84.00 | 2.42 | 0.02 | 0.06 | 9.86 | 5.05 | 371.98 | 60.78 | 17.14 | 5.49 | 2.22 |
| 76 | 762.80 | 131.34 | 244.65 | 20.91 | 243.49 | 320.04 | 758.86 | 10.19 | 1.31 | 29.36 | 2.51 | 30.14 | 28.32 | 84.00 | 2.45 | 0.02 | 0.06 | 10.06 | 5.06 | 372.21 | 60.81 | 17.17 | 5.49 | 2.22 |
| 77 | 762.80 | 133.79 | 242.85 | 20.76 | 241.71 | 320.04 | 758.51 | 10.32 | 1.34 | 29.14 | 2.49 | 29.88 | 28.32 | 84.00 | 2.49 | 0.02 | 0.05 | 10.27 | 5.07 | 372.41 | 60.84 | 17.18 | 5.49 | 2.22 |
| 78 | 762.80 | 136.27 | 241.20 | 20.62 | 240.07 | 320.04 | 757.98 | 10.45 | 1.36 | 28.94 | 2.47 | 29.64 | 28.32 | 84.00 | 2.52 | 0.02 | 0.05 | 10.48 | 5.06 | 372.61 | 60.87 | 17.20 | 5.49 | 2.22 |
| 79 | 762.80 | 140.21 | 239.27 | 20.45 | 238.16 | 320.04 | 756.30 | 10.72 | 1.40 | 28.71 | 2.45 | 29.35 | 28.32 | 84.00 | 2.59 | 0.03 | 0.05 | 10.84 | 5.07 | 372.82 | 60.90 | 17.23 | 5.49 | 2.23 |
| 80 | 762.80 | 142.78 | 237.78 | 20.33 | 236.68 | 320.04 | 755.52 | 10.87 | 1.43 | 28.53 | 2.44 | 29.13 | 28.32 | 84.00 | 2.62 | 0.03 | 0.05 | 11.06 | 5.08 | 373.04 | 60.93 | 17.24 | 5.49 | 2.23 |
| 81 | 762.80 | 145.07 | 236.62 | 20.23 | 235.52 | 320.04 | 754.68 | 10.98 | 1.45 | 28.39 | 2.43 | 28.97 | 28.32 | 84.00 | 2.65 | 0.03 | 0.05 | 11.26 | 5.08 | 373.28 | 60.97 | 17.25 | 5.49 | 2.23 |
| 82 | 762.80 | 147.22 | 235.32 | 20.12 | 234.23 | 320.04 | 754.13 | 11.10 | 1.47 | 28.24 | 2.41 | 28.78 | 28.32 | 84.00 | 2.68 | 0.03 | 0.05 | 11.44 | 5.09 | 373.52 | 61.00 | 17.25 | 5.49 | 2.23 |
| 83 | 762.80 | 149.14 | 234.17 | 20.02 | 233.10 | 320.04 | 753.30 | 11.15 | 1.49 | 28.10 | 2.40 | 28.63 | 28.32 | 84.00 | 2.69 | 0.03 | 0.05 | 11.59 | 5.02 | 373.33 | 60.98 | 17.26 | 5.49 | 2.23 |
| 84 | 762.80 | 151.00 | 233.09 | 19.93 | 232.02 | 320.04 | 752.30 | 11.20 | 1.51 | 27.97 | 2.39 | 28.49 | 28.32 | 84.00 | 2.70 | 0.03 | 0.05 | 11.74 | 4.94 | 372.89 | 60.91 | 17.27 | 5.49 | 2.23 |
| 85 | 762.80 | 152.84 | 232.29 | 19.86 | 231.23 | 320.04 | 751.20 | 11.25 | 1.53 | 27.87 | 2.38 | 28.39 | 28.32 | 84.00 | 2.72 | 0.03 | 0.05 | 11.89 | 4.90 | 372.70 | 60.88 | 17.27 | 5.49 | 2.22 |
| 86 | 762.80 | 186.19 | 213.89 | 18.29 | 212.93 | 320.04 | 743.47 | 13.65 | 3.72 | 25.67 | 2.19 | 24.73 | 28.32 | 84.00 | 3.30 | 0.03 | 0.05 | 14.81 | 5.67 | 380.57 | 62.00 | 17.18 | 5.49 | 2.32 |
| 87 | 762.80 | 188.78 | 212.10 | 18.13 | 211.15 | 320.04 | 742.83 | 13.85 | 3.78 | 25.45 | 2.18 | 24.46 | 28.32 | 84.00 | 3.35 | 0.03 | 0.05 | 15.05 | 5.75 | 380.61 | 62.00 | 17.18 | 5.49 | 2.32 |
| 88 | 762.80 | 191.38 | 210.36 | 17.99 | 209.42 | 320.04 | 742.17 | 14.00 | 3.83 | 25.24 | 2.16 | 24.31 | 28.32 | 84.00 | 3.39 | 0.03 | 0.05 | 15.29 | 5.79 | 380.73 | 62.01 | 16.98 | 5.49 | 2.32 |
| 89 | 762.80 | 193.99 | 208.97 | 17.87 | 208.03 | 320.04 | 741.17 | 14.27 | 3.88 | 25.08 | 2.14 | 24.09 | 28.32 | 84.00 | 3.46 | 0.03 | 0.05 | 15.53 | 5.99 | 380.90 | 62.04 | 16.98 | 5.49 | 2.32 |
| 90 | 762.80 | 196.60 | 207.56 | 17.75 | 206.63 | 320.04 | 740.19 | 14.07 | 3.93 | 24.91 | 2.13 | 23.87 | 28.32 | 84.00 | 3.41 | 0.03 | 0.05 | 15.77 | 5.45 | 381.13 | 62.07 | 16.98 | 5.49 | 2.32 |
| 91 | 762.80 | 199.20 | 205.93 | 17.61 | 205.01 | 320.04 | 739.43 | 14.08 | 3.98 | 24.71 | 2.11 | 23.63 | 28.32 | 84.00 | 3.41 | 0.03 | 0.05 | 16.02 | 5.24 | 381.26 | 62.09 | 16.96 | 5.49 | 2.33 |
| 92 | 762.80 | 201.61 | 204.40 | 17.48 | 203.49 | 320.04 | 738.74 | 14.17 | 6.05 | 24.53 | 2.10 | 23.40 | 28.32 | 84.00 | 3.43 | 0.03 | 0.05 | 16.25 | 5.18 | 381.40 | 62.11 | 16.96 | 5.49 | 2.33 |

Description of Variables:

| | |
|---|---|
| CN2 | Runoff curve number, antecedent moisture condition 2 |
| COTP | Crop yield for picker cotton (t/ha) |
| DN | N loss by denitrification (kg/ha) |
| DRNN | Mineral N loss in subsurface drain flow (kg/ha) |
| DRT | Drain time, days required for drainage to reduce plant stress (days) |
| ET | Evapotranspiration (mm) |
| FNH3 | Fertilizer N applied in the form $NH_3$-N (kg/ha) |
| FNO3 | Fertilizer N applied in the form $NO_3$-N (kg/ha) |
| GRSG | Crop yield for grain sorghum (t/ha) |
| IRGA | Irrigation water applied (mm) |
| MUSS | Soil loss from water erosion using a modified MUSLE option for small watersheds |
| PRCP | Precipitation (mm) |
| PRK | Percolation below the root zone (mm) |
| PRKN | Mineral N loss in percolate (kg/ha) |
| PRKP | Percolation of P below the root zone (kg/ha) |
| Q | Runoff (mm) |
| QDRN | Subsurface drain flow (mm) |
| SSF | Lateral subsurface flow (mm) |
| SSFN | Mineral N loss in subsurface flow (kg/ha) |
| UNO3 | N uptake by the crop (kg/ha) |
| UPP | P uptake by the crop (kg/ha) |
| WNO3 | Initial nitrate concentration in the soil (ppm) |
| YAP | Soluble P loss in runoff (kg/ha) |
| YNO3 | NO3 loss in surface runoff (kg/ha) |
| YON | Organic N loss with sediment (kg/ha) |
| YP | P loss with sediment (kg/ha) |
| YW | Soil loss from wind erosion (t/ha) |

# EPIC Variable CN2, Runoff Curve Number - Antecedent Moisture Condition 2
## % Change

| CN2 | PRCP | Q | SSF | PRK | QDRN | IRGA | ET | YON | YNO3 | SSFN | PRKN | DRNN | FNO3 | FNH3 | YP | YAP | PRKP | MUSS | YW | UNO3 | UPP | DN | GRSG | COTP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -9% | 0.0% | -9.4% | 3.3% | 3.3% | 3.3% | 0.0% | 0.5% | -8.1% | -9.4% | 3.3% | 3.3% | 3.9% | 0.0% | 0.0% | -8.3% | -9.4% | 3.4% | -12.7% | -0.6% | -0.4% | -0.4% | -0.3% | 0.0% | -0.9% |
| -7% | 0.0% | -11.1% | 4.2% | 4.2% | 4.2% | 0.0% | 0.6% | -8.4% | -11.1% | 4.2% | 4.2% | 5.0% | 0.0% | 0.0% | -8.7% | -11.1% | 4.3% | -12.4% | -0.5% | -0.3% | -0.3% | -0.6% | 0.0% | -0.7% |
| -6% | 0.0% | -9.5% | 3.4% | 3.4% | 3.4% | 0.0% | 0.6% | -7.2% | -9.5% | 3.4% | 3.4% | 4.1% | 0.0% | 0.0% | -7.4% | -9.5% | 3.6% | -10.6% | -0.3% | -0.3% | -0.3% | -0.5% | 0.0% | -0.6% |
| -5% | 0.0% | -7.8% | 2.6% | 2.6% | 2.6% | 0.0% | 0.5% | -6.0% | -7.8% | 2.6% | 2.6% | 3.2% | 0.0% | 0.0% | -6.2% | -7.8% | 2.8% | -8.8% | -0.2% | -0.2% | -0.2% | -0.4% | 0.0% | -0.5% |
| -4% | 0.0% | -6.1% | 1.9% | 1.9% | 1.9% | 0.0% | 0.4% | -4.9% | -6.1% | 1.9% | 1.9% | 2.3% | 0.0% | 0.0% | -5.0% | -6.1% | 2.1% | -6.9% | -0.3% | -0.2% | -0.2% | -0.3% | 0.0% | -0.4% |
| -2% | 0.0% | -3.4% | 1.1% | 1.1% | 1.1% | 0.0% | 0.2% | -2.4% | -3.4% | 1.1% | 1.1% | 1.3% | 0.0% | 0.0% | -2.4% | -3.4% | 1.1% | -3.7% | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | -0.3% |
| -1% | 0.0% | -1.6% | 0.5% | 0.5% | 0.5% | 0.0% | 0.1% | -1.1% | -1.6% | 0.5% | 0.5% | 0.6% | 0.0% | 0.0% | -1.1% | -1.6% | 0.6% | -1.7% | 0.1% | -0.1% | -0.1% | -0.1% | 0.0% | -0.1% |
| 0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1% | 0.0% | 1.5% | -0.6% | -0.5% | -0.5% | 0.0% | -0.1% | 1.1% | 1.5% | -0.6% | -0.5% | -0.6% | 0.0% | 0.0% | 1.1% | 1.5% | -0.6% | 1.6% | 0.2% | 0.1% | 0.1% | 0.0% | 0.0% | 0.1% |
| 2% | 0.0% | 2.8% | -1.0% | -1.0% | -1.0% | 0.0% | -0.2% | 1.5% | 2.8% | -1.0% | -1.0% | -1.2% | 0.0% | 0.0% | 1.6% | 2.8% | -0.9% | 3.0% | -1.2% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% |
| 4% | 0.0% | 4.1% | -1.5% | -1.5% | -1.5% | 0.0% | -0.3% | 1.9% | 4.1% | -1.5% | -1.5% | -1.6% | 0.0% | 0.0% | 2.0% | 4.1% | -1.5% | 4.3% | -2.6% | -0.1% | -0.1% | 0.1% | 0.0% | -0.2% |
| 5% | 0.0% | 5.4% | -1.8% | -1.8% | -1.8% | 0.0% | -0.5% | 2.5% | 5.4% | -1.8% | -1.8% | -2.0% | 0.0% | 0.0% | 2.6% | 5.4% | -1.9% | 5.6% | -3.6% | -0.2% | -0.1% | 0.1% | 0.0% | -0.3% |
| 6% | 0.0% | 28.3% | -9.6% | -9.6% | -9.6% | 0.0% | -1.5% | 24.3% | 156.7% | -9.6% | -9.6% | -14.6% | 0.0% | 0.0% | 24.7% | 21.2% | -9.8% | 31.5% | 11.6% | 2.0% | 1.7% | -0.4% | 0.0% | 3.9% |
| 7% | 0.0% | 30.1% | -10.4% | -10.4% | -10.3% | 0.0% | -1.6% | 26.1% | 160.3% | -10.4% | -10.4% | -15.5% | 0.0% | 0.0% | 26.5% | 22.9% | -10.5% | 33.7% | 13.3% | 2.0% | 1.7% | -0.4% | 0.0% | 3.9% |
| 9% | 0.0% | 31.9% | -11.1% | -11.1% | -11.1% | 0.0% | -1.7% | 27.5% | 163.8% | -11.1% | -11.1% | -16.1% | 0.0% | 0.0% | 27.9% | 24.6% | -11.3% | 35.8% | 13.9% | 2.0% | 1.7% | -1.5% | 0.0% | 4.0% |
| 10% | 0.0% | 33.7% | -11.7% | -11.7% | -11.7% | 0.0% | -1.8% | 29.9% | 167.4% | -11.7% | -11.7% | -16.8% | 0.0% | 0.0% | 30.4% | 26.3% | -11.9% | 38.0% | 18.0% | 2.0% | 1.8% | -1.6% | 0.0% | 4.1% |
| 11% | 0.0% | 35.5% | -12.3% | -12.3% | -12.3% | 0.0% | -1.9% | 28.1% | 171.0% | -12.3% | -12.3% | -17.6% | 0.0% | 0.0% | 28.5% | 28.0% | -12.6% | 40.1% | 7.3% | 2.1% | 1.8% | -1.5% | 0.0% | 4.1% |
| 12% | 0.0% | 37.3% | -13.0% | -13.0% | -13.0% | 0.0% | -2.0% | 28.2% | 174.6% | -13.0% | -13.0% | -18.4% | 0.0% | 0.0% | 28.7% | 29.7% | -13.2% | 42.3% | 3.2% | 2.1% | 1.8% | -1.6% | 0.0% | 4.2% |
| 14% | 0.0% | 39.0% | -13.6% | -13.6% | -13.6% | 0.0% | -2.1% | 29.0% | 316.9% | -13.6% | -13.6% | -19.2% | 0.0% | 0.0% | 29.5% | 31.3% | -13.9% | 44.4% | 2.0% | 2.2% | 1.9% | -1.7% | 0.0% | 4.3% |

## APPENDIX H

## Representative Crop Management Schedules

### Furrow Irrigated Cotton - Baseline BMP, Current Conditions

| Dry year / Normal year / Wet year | Mo | Day | Picker Cotton EPIC Crop # in USDACROP DAT = 5, PHU=2900 — Operation | EPIC Tillage # | Irrigation Volume mm | Irrigation Volume in | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Appl. Rates (Active Ingredient) kg/ha | Pesticide Appl. Rates (Active Ingredient) lb/ac | N Application Rates kg/ha | N Application Rates lb/ac | P Application Rates (as P) $P_2O_5 = 2.27P$ kg/ha | P Application Rates (as P) $P_2O_5 = 2.27P$ lb/ac |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N,W | 1 | 10 | Apply preemergent herbicide, soil incorporated (top 2") | 6 | | | 255 | Treflan (Trifluralin) | 1.68 | 1.50 | | | | |
| N,W | 1 | 20 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 67.25 | 60 | 29.59 | 26.4 |
| | 2 | 1 | **Border Ditching, forming block ends in preparation for furrow irrigation** | 80 | | | | | | | | | | |
| | 2 | 2 | **Furrow Irrigation** | 72 | 152 | 6 | | | | | | | | |
| N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| N,W | 2 | 20 | Plant picker cotton with row planter, Potential Heat Units for crop = 2900 | 2 | | | | | | | | | | |
| N,W | 3 | 15 | Cultivate | 19 | | | | | | | | | | |
| N,W | 3 | 15 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N,W | 3 | 16 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 4 | 5 | Apply insecticide to control overwintering/inseason cotton boll weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| N | 4 | 14 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N | 4 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 4 | 20 | Apply insecticide to control overwintering/inseason cotton boll weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| N,W | 5 | 14 | Cultivate | 19 | | | | | | | | | | |
| N | 5 | 14 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N | 5 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 5 | 20 | Apply insecticide to control inseason cotton boll weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| N,W | 6 | 5 | Apply dual purpose insecticide to control weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| N,W | 6 | 14 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N,W | 6 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 6 | 15 | Apply dual purpose insecticide to control weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| N,W | 6 | 20 | Apply dual purpose (pyrethroid) insecticide to control both weevils and worms | 11 | | | 130 | Karate (Cyhalothrin) | 0.03 | 0.03 | | | | |
| N,W | 7 | 5 | Apply dual purpose (pyrethroid) insecticide to control both weevils and worms | 11 | | | 130 | Karate (Cyhalothrin) | 0.03 | 0.03 | | | | |
| | 7 | 14 | **Border Ditching, forming block ends in preparation for furrow irrigation** | 80 | | | | | | | | | | |
| | 7 | 15 | **Furrow Irrigation** | 72 | 152 | 6 | | | | | | | | |
| | 7 | 15 | **Apply dual purpose insecticide to control weevils** | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| W | 7 | 20 | **Apply dual purpose (pyrethroid) insecticide to control both weevils and worms** | 11 | | | 130 | Karate (Cyhalothrin) | 0.03 | 0.03 | | | | |
| N,W | 8 | 5 | Apply defoliant (29% use Dropp/ 71% use DEF) | 11 | | | 96 | Dropp (Thidiazuron) | 0.17 | 0.15 | | | | |
| N,W | 8 | 5 | Apply defoliant (29% use Dropp/ 71% use DEF) | 11 | | | 83 | DEF (Tribufos or Phosphorotrithioate) | 1.23 | 1.10 | | | | |
| N,W | 8 | 20 | Harvest - picker cotton | 51 | | | | | | | | | | |
| N,W | 8 | 20 | Kill cotton crop | 41 | | | | | | | | | | |
| N,W | 8 | 25 | Shredding | 57 | | | | | | | | | | |
| N,W | 9 | 1 | Plowing | 24 | | | | | | | | | | |
| N,W | 9 | 5 | Sweep Chisel | 32 | | | | | | | | | | |
| N,W | 9 | 10 | Discing offset | 33 | | | | | | | | | | |
| N,W | 9 | 15 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 9 | 20 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 12 | 15 | Bedding | 15 | | | | | | | | | | |

...nges in pesticide applications or irrigations due to rainfall conditions
...er normal rainfall conditions, denoted (N), 8 insecticide applications are generally sufficient to control cotton pests
Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop
One preplant herbicide application for weed control
...ring wet years, denoted with a (W), two additional applications, (1) of Guthion and (1) of Karate, may be required
Two irrigations of 6" each supply 12" of irrigation water at 2/3 efficiency = 8" of water supplied to crop
...ring dry years (D), one less Guthion application may be sufficient
Six irrigations of 6" each supply 36" of irrigation water at 2/3 efficiency = 24" of water supplied to crop

**This represents IPM (Full Implementation)**
**For mid-level IPM, add 1 Guthion and 1 Karate application (6/1 and 6/10)**
**For low-level IPM, add 2 more Guthion applications (7/1 and 7/10)**
**and 1 Orthene application for aphids at 0.4 lb/acre (5/1)**

## Dryland Cotton - Baseline BMP, Current Conditions

| D=Dry year N=Normal year W=Wet year | Picker Cotton - EPIC Crop # in USDACROP.DAT = 5, PHU=2900 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5$ = 2.27P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D,N,W | 1 | 10 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 33.6 | 30 | 14.8 | 13 |
| D,N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 2 | 15 | Plant picker cotton with row planter. Potential Heat Units for crop = 2900 | 2 | | | | | | | | | | |
| D,N,W | 2 | 15 | Apply preemergent herbicide, soil incorporated (top 2") | 6 | | | 255 | Treflan (Trifluralin) | 1.68 | 1.50 | | | | |
| D,N,W | 3 | 15 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 4 | 20 | Apply insecticide to control cotton fleahoppers | 11 | | | 43 | Bidrin (Dicrotophos) | 0.22 | 0.20 | | | | |
| D,N,W | 5 | 20 | Cultivate | 19 | | | | | | | | | | |
| N,W | 6 | 1 | Apply insecticide to control overwintering/inseason cotton boll weevils | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| D,N,W | 6 | 20 | Apply dual purpose (pyrethroid) insecticide to control both weevils and worms | 11 | | | 122 | Guthion (Azinphos-methyl) | 0.28 | 0.25 | | | | |
| D,N,W | 7 | 5 | Apply dual purpose (pyrethroid) insecticide to control both weevils and worms | 11 | | | 130 | Karate (Cyhalothrin) | 0.03 | 0.03 | | | | |
| D,N,W | 8 | 5 | Apply defoliant (29% use Dropp/ 71% use DEF) | 11 | | | 96 | Dropp (Thidiazuron) | 0.17 | 0.15 | | | | |
| D,N,W | 8 | 5 | Apply defoliant (29% use Dropp/ 71% use DEF) | 11 | | | 83 | DEF (Tribufos or Phosphorotrithioate) | 1.23 | 1.10 | | | | |
| D,N,W | 8 | 20 | Harvest - picker cotton | 51 | | | | | | | | | | |
| D,N,W | 8 | 20 | Kill cotton crop | 41 | | | | | | | | | | |
| D,N,W | 8 | 25 | Shredding | 57 | | | | | | | | | | |
| D,N,W | 9 | 1 | Plowing | 24 | | | | | | | | | | |
| D,N,W | 9 | 5 | Sweep Chisel | 32 | | | | | | | | | | |
| D,N,W | 9 | 10 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 9 | 15 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 9 | 20 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 12 | 15 | Bedding | 15 | | | | | | | | | | |

Changes in pesticide applications due to rainfall conditions

Under normal rainfall conditions, denoted with an (N), four insecticide applications are generally sufficient to control cotton pests

One preemergent herbicide application for weed control at planting

During dry years, denoted with a (D), one less Guthion application may be sufficient

## urrow Irrigated Grain Sorghum - Baseline BMP, Current Conditions

| Dry year / Normal year / Wet year | Grain Sorghum - EPIC Crop # in USDACROP.DAT = 3, PHU=2000 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 1 | 10 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 135 | 120 | 29.6 | 26 |
| N,W | 1 | 15 | Cultivate | 19 | | | | | | | | | | |
| N,W | 2 | 10 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| N,W | 2 | 15 | Plant grain sorghum with row planter, Potential Heat Units for crop = 2000 | 2 | | | | | | | | | | |
| N,W | 3 | 15 | Apply post emergent herbicide, incorporated (culti-spray) | 6 | | | 255 | Treflan (Trifluralin) | 0.78 | 0.70 | | | | |
| N,W | 3 | 15 | Cultivate | 19 | | | | | | | | | | |
| | 3 | 15 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| | 3 | 16 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 4 | 14 | Cultivate | 19 | | | | | | | | | | |
| N | 4 | 14 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N | 4 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N | 5 | 14 | Border Ditching, forming block ends in preparation for furrow irrigation | 80 | | | | | | | | | | |
| N | 5 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 7 | 20 | Harvest - grain sorghum | 51 | | | | | | | | | | |
| N,W | 9 | 10 | Kill sorghum crop | 41 | | | | | | | | | | |
| N,W | 9 | 10 | Shredding | 57 | | | | | | | | | | |
| N,W | 9 | 15 | Sweep-chisel | 32 | | | | | | | | | | |
| N,W | 9 | 20 | Discing offset | 33 | | | | | | | | | | |
| N,W | 10 | 15 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 11 | 15 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 12 | 15 | Bedding | 15 | | | | | | | | | | |

anges in pesticide applications or irrigations due to rainfall conditions
for normal rainfall conditions.
Grain sorghum crops in the area typically do not receive insecticide applications
One preemergent herbicide application at planting
Two irrigations (Denoted with N) of 6" each supply 12" of irrigation water at 2/3 efficiency = 8" of water supplied to crop
ring wet years,
rigation not required
ring dry years,
Three irrigations (Denoted with D) of 6" each supply 18" of irrigation water at 2/3 efficiency = 12" of water supplied to crop

## Dryland Grain Sorghum - Baseline BMP, Current Conditions

| D=Dry year<br>N=Normal year<br>W=Wet year | Grain Sorghum - EPIC Crop # in USDACROP.DAT = 3, PHU=2000 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D,N,W | 1 | 15 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 33.63 | 30 | | |
| D,N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 2 | 15 | Plant grain sorghum with row planter, Potential Heat Units for crop = 2000 | 2 | | | | | | | | | | |
| D,N,W | 3 | 15 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 5 | 15 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 7 | 20 | Harvest - grain sorghum | 51 | | | | | | | | | | |
| D,N,W | 9 | 10 | Kill sorghum crop | 41 | | | | | | | | | | |
| D,N,W | 9 | 10 | Shredding | 57 | | | | | | | | | | |
| D,N,W | 9 | 15 | Plowing | 24 | | | | | | | | | | |
| D,N,W | 9 | 16 | Sweep-chisel | 32 | | | | | | | | | | |
| D,N,W | 9 | 20 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 10 | 15 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 11 | 15 | Bedding | 15 | | | | | | | | | | |

Changes in management due to rainfall conditions

Under normal rainfall conditions.

Grain sorghum crops in the area typically do not receive insecticide applications

No herbicide or insecticide applications under normal conditions

## urrow Irrigated Corn - Baseline BMP, Current Conditions

| Dry year / Normal year / Wet year | Corn - EPIC Crop # in USDACROP.DAT = 2, PHU=1950 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5$ = 2.27P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 1 | 15 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 168 | 150 | 24.7 | 22 |
| N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| N,W | 2 | 10 | Border Ditching, forming block ends for furrow irrigation | 80 | | | | | | | | | | |
| N,W | 2 | 15 | Plant corn with row planter, Potential Heat Units for crop = 1950 | 2 | | | | | | | | | | |
| N,W | 2 | 15 | Apply preemergent herbicide, surface applied | 6 | | | 255 | Prowl (Pendimethalin) | 0.78 | 0.70 | | | | |
| N,W | 3 | 10 | Cultivate | 19 | | | | | | | | | | |
| | 3 | 15 | Border Ditching, forming block ends for furrow irrigation | 80 | | | | | | | | | | |
| | 3 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 4 | 10 | Cultivate | 19 | | | | | | | | | | |
| N | 4 | 15 | Border Ditching, forming block ends for furrow irrigation | 80 | | | | | | | | | | |
| N | 4 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N | 5 | 15 | Border Ditching, forming block ends for furrow irrigation | 80 | | | | | | | | | | |
| N | 5 | 15 | Furrow Irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 6 | 20 | Harvest - Corn | 51 | | | | | | | | | | |
| N,W | 9 | 10 | Kill corn crop | 41 | | | | | | | | | | |
| N,W | 9 | 10 | Shredding | 57 | | | | | | | | | | |
| N,W | 9 | 15 | Sweep-chisel | 32 | | | | | | | | | | |
| N,W | 9 | 20 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 10 | 15 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 11 | 15 | Discing-offset | 33 | | | | | | | | | | |
| N,W | 12 | 15 | Bedding | 15 | | | | | | | | | | |

ianges in irrigations due to rainfall conditions
rmal rainfall conditions (denoted with N)
Two irrigations of 6" each supply 12" of irrigation water at 2/3 efficiency = 8" of water supplied to crop
ring wet years (denoted with W)
Irrigation not required
ring dry years (denoted with D)
Three irrigations of 6" each supply 18" of irrigation water at 2/3 efficiency = 12" of water supplied to crop

sticide Applications
One preemergent herbicide application at planting

## Dryland Corn - Baseline BMP, Current Conditions

| D=Dry year<br>N=Normal year<br>W=Wet year | Corn - EPIC Crop # in USDACROP.DAT = 2, PHU=1950 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D,N,W | 1 | 15 | Apply fertilizer (dry, surface applied ) | 10 | | | | | | | 84.07 | 75 | | |
| D,N,W | 2 | 10 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 2 | 15 | Plant corn with row planter, Potential Heat Units for crop = 1950 | 2 | | | | | | | | | | |
| D,N,W | 3 | 10 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 4 | 10 | Cultivate | 19 | | | | | | | | | | |
| D,N,W | 6 | 20 | Harvest - Corn | 51 | | | | | | | | | | |
| D,N,W | 9 | 10 | Kill corn crop | 41 | | | | | | | | | | |
| D,N,W | 9 | 10 | Shredding | 57 | | | | | | | | | | |
| D,N,W | 9 | 15 | Plowing | 24 | | | | | | | | | | |
| D,N,W | 9 | 16 | Sweep-chisel | 32 | | | | | | | | | | |
| D,N,W | 9 | 20 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 10 | 15 | Discing-offset | 33 | | | | | | | | | | |
| D,N,W | 11 | 15 | Bedding | 15 | | | | | | | | | | |

Assumed the same management for wet, normal and dry years

# urrow Irrigated Sugarcane (Plant Cane) - Baseline BMP, Current Conditions

| Dry year / Normal year / Wet year | Sugarcane (Plant Cane) - EPIC Crop # in USDACROP.DAT = 77 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 9 | 1 | weed disking or shredding or previous crop | 57 | | | | | | | | | | |
| N,W | 9 | 3 | Plowing or deep subsoil ripping | 34 | | | | | | | | | | |
| N,W | 9 | 4 | Surface disking | 33 | | | | | | | | | | |
| N,W | 9 | 5 | Land planing (laser leveling) | - | | | | | | | | | | |
| N,W | 9 | 13 | drawing of plant furrows | 15 | | | | | | | | | | |
| N,W | 9 | 14 | fertilizer application (fertilizer #64) | 10 | | | | | | | 89.6 | 80 | | |
| N,W | 9 | 14 | fertilizer application (fertilizer #65) | 10 | | | | | | | | | 49.28 | 44 |
| N,W | 9 | 15 | planting/seed covering (4 6 tons/acre) | 2 | | | | | | | | | | |
| N,W | 9 | 16 | herbicide application (pre-emergence) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| N,W | 9 | 16 | herbicide application (pre emergence) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| N,W | 9 | 17 | build borders | 80 | | | | | | | | | | |
| N,W | 9 | 18 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| | 10 | 18 | **furrow irrigation (dry years only)** | 72 | 152.4 | 6 | | | | | | | | |
| N,W | 11 | 20 | knock down borders | 77 | | | | | | | | | | |
| N,W | 11 | 21 | cultivate and reshape cane rows | 19 | | | | | | | | | | |
| N,W | 12 | 21 | cultivate and reshape cane rows | 19 | | | | | | | | | | |
| N,W | 1 | 25 | cultivate interrows | 19 | | | | | | | | | | |
| N,W | 2 | 10 | herbicide application (post emergence) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| N,W | 2 | 10 | herbicide application (post-emergence) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| N,W | 4 | 13 | rebuild borders | 80 | | | | | | | | | | |
| N,W | 4 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 32 | Banvel (Dicambra Soluble Salt) | 0.56 | 0.50 | | | | |
| N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 204 | Roundup (Glyphosate Amine) | 2.24 | 2.00 | | | | |
| N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 109 | Evik (Ametryn) | 1.792 | 1.60 | | | | |
| | 5 | 22 | **furrow irrigation (dry years only)** | 72 | 152.4 | 6 | | | | | | | | |
| N | 6 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N | 7 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N,W | 7 | 14 | knock down and rebuild weedy borders | 80 | | | | | | | | | | |
| N,W | 7 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N | 8 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N,W | 8 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N | 9 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| N,W | 1 | 3 | knock down borders (pre-harvest preparation) | 77 | | | | | | | | | | |
| N,W | 1 | 4 | harrow turnrows (pre-harvest preparation) | 25 | | | | | | | | | | |
| N,W | 1 | 5 | burn & harvest | 53 | | | | | | | | | | |

anges in irrigations due to rainfall conditions
der normal rainfall conditions (denoted with N),
ight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop
ring wet years (denoted with W),
our irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency [illegible] 16" of water supplied to crop
ring dry years (denoted with D),
Ten irrigations of 6" each supply 60" of irrigation water at 2/3 efficiency = 40" of water supplied to crop

<u>Herbicide Applications (3 applications/year)</u>
Fall pre-emergence applications (9/16) of
Aatrex (Atrazine) & Prowl (Pendimethalin)
Winter post-emergence applications (2/10)
of the same two herbicides
Spring spot sprays (5/10) for misses

## Furrow Irrigated Sugarcane (Plant Cane) - BMP #1, Nutrient Management

| D=Dry year<br>N=Normal year<br>W=Wet year | Sugarcane (Plant Cane) -<br>EPIC Crop # in USDACROP.DAT = 77 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5$ = 2.27P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D,N,W | 9 | 1 | weed disking or shredding or previous crop | 57 | | | | | | | | | | |
| D,N,W | 9 | 3 | Plowing or deep subsoil ripping | 34 | | | | | | | | | | |
| D,N,W | 9 | 4 | Surface disking | 33 | | | | | | | | | | |
| D,N,W | 9 | 5 | Land planing (laser leveling) | - | | | | | | | | | | |
| D,N,W | 9 | 13 | drawing of plant furrows | 15 | | | | | | | | | | |
| D,N,W | 9 | 14 | fertilizer application 11-37-0 (200 lbs/acre) Fertilizer #52 | 10 | | | | | | | 24.64 | 22 | 82.88 | 74 |
| D,N,W | 9 | 15 | planting/seed covering (4-6 tons/acre) | 2 | | | | | | | | | | |
| D,N,W | 9 | 16 | herbicide application (pre-emergence) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| D,N,W | 9 | 16 | herbicide application (pre-emergence) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| D,N,W | 9 | 17 | build borders | 80 | | | | | | | | | | |
| D,N,W | 9 | 18 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D | 10 | 18 | furrow irrigation (dry years only) | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 11 | 20 | knock down borders | 77 | | | | | | | | | | |
| D,N,W | 11 | 21 | cultivate and reshape cane rows | 19 | | | | | | | | | | |
| D,N,W | 12 | 21 | cultivate and reshape cane rows | 19 | | | | | | | | | | |
| D,N,W | 1 | 25 | cultivate interrows | 19 | | | | | | | | | | |
| D,N,W | 2 | 10 | herbicide application (post-emergence) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| D,N,W | 2 | 10 | herbicide application (post-emergence) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| D,N,W | 4 | 13 | rebuild borders | 80 | | | | | | | | | | |
| D,N,W | 4 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 32 | Banvel (Dicambra Soluble Salt) | 0.56 | 0.50 | | | | |
| D,N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 204 | Roundup (Glyphosate Amine) | 2.24 | 2.00 | | | | |
| D,N,W | 5 | 10 | spot spray or aerial application of herbicides | 11 | | | 109 | Evik (Ametryn) | 1.79 | 1.60 | | | | |
| D | 5 | 22 | furrow irrigation (dry years only) | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 6 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 7 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 7 | 14 | knock down and rebuild weedy borders | 80 | | | | | | | | | | |
| D,N,W | 7 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 8 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 8 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 9 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 1 | 3 | knock down borders (pre-harvest preparation) | 77 | | | | | | | | | | |
| D,N,W | 1 | 4 | harrow turnrows (pre-harvest preparation) | 25 | | | | | | | | | | |
| D,N,W | 1 | 5 | burn & harvest | 53 | | | | | | | | | | |

Changes in irrigations due to rainfall conditions

Under normal rainfall conditions (denoted with N),
Eight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop

During wet years (denoted with W),
Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop

During dry years (denoted with D),
Ten irrigations of 6" each supply 60" of irrigation water at 2/3 efficiency = 40" of water supplied to crop

Herbicide Applications (3 applications/year)

Fall pre-emergence applications (9/16) of
Aatrex (Atrazine) & Prowl (Pendimethalin)

Winter post-emergence applications (2/10)
of the same two herbicides

Spring spot sprays (5/10) for misses

## ıcpresentative Management for Furrow Irrigated Sugarcane (Ratoon Cane) - Baseline BMP, current conditions

| D Dry year<br>Normal year<br>W Wet year | Sugarcane (Ratoon Cane) - EPIC Crop # in USDACROP.DAT = 77 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 1 | 13 | interrow gang harrow | 25 | | | | | | | | | | |
| N,W | 1 | 14 | subsoil | 34 | | | | | | | | | | |
| N,W | 1 | 15 | fertilize (liquid N-32, incorporated) | 13 | | | | | | | 201.6 | 180 | - | - |
| N,W | 1 | 15 | cultivation - reshape | 19 | | | | | | | | | | |
| N,W | 1 | 20 | herbicide application (sprayer) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| N,W | 1 | 20 | herbicide application (sprayer) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| N,W | 1 | 23 | border building | 80 | | | | | | | | | | |
| N,W | 1 | 24 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| | 3 | 15 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 4 | 12 | knock down borders | 77 | | | | | | | | | | |
| N,W | 4 | 12 | cultivate weeds | 19 | | | | | | | | | | |
| N,W | 4 | 13 | herbicide application (sprayer) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| N,W | 4 | 13 | herbicide application (sprayer) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| N,W | 4 | 14 | rebuild borders | 80 | | | | | | | | | | |
| N,W | 4 | 15 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| | 5 | 1 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 32 | Banvel (Dicambra Soluble Salt) | 0.56 | 0.50 | | | | |
| N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 204 | Roundup (Glyphosate Amine) | 2.24 | 2.00 | | | | |
| N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 109 | Evik (Ametryn) | 1.792 | 1.60 | | | | |
| N | 5 | 22 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 6 | 15 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 7 | 1 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 7 | 14 | rebuild borders | 80 | | | | | | | | | | |
| N | 7 | 15 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N | 8 | 1 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 8 | 15 | furrow irrigation | 72 | 152 | 6 | | | | | | | | |
| N,W | 12 | 3 | knock down borders (pre-harvest preparation) | 77 | | | | | | | | | | |
| N,W | 12 | 3 | harrow turnrows (pre-harvest preparation) | 25 | | | | | | | | | | |
| N,W | 1 | 6 | burn & harvest | 53 | | | | | | | | | | |

anges in irrigations due to rainfall conditions
ıder normal rainfall conditions (denoted with N).
Eight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop
ıring wet years (denoted with W).
Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop
ıring dry years (denoted with D)
Ten irrigations of 6" each supply 60" of irrigation water at 2/3 efficiency = 40" of water supplied to crop

ıee herbicide applications (1/20, 4/13, and 5/20)

## Furrow Irrigated Sugarcane (Ratoon Cane) - BMP #1, Nutrient Management

| D=Dry year N=Normal year W=Wet year | Sugarcane (Ratoon Cane) - EPIC Crop # in USDACROP DAT = 77 | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5$ = 2.27P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D,N,W | 1 | 13 | interrow gang harrow | 25 | | | | | | | | | | |
| D,N,W | 1 | 14 | subsoil | 34 | | | | | | | | | | |
| D,N,W | 1 | 15 | fertilize (liquid N-32, incorporated) | 13 | | | | | | | ** | ** | - | - |
| D,N,W | 1 | 15 | cultivation - reshape | 19 | | | | | | | | | | |
| D,N,W | 1 | 20 | herbicide application (sprayer) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| D,N,W | 1 | 20 | herbicide application (sprayer) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| D,N,W | 1 | 23 | border building | 80 | | | | | | | | | | |
| D,N,W | 1 | 24 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D | 3 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 4 | 12 | knock down borders | 77 | | | | | | | | | | |
| D,N,W | 4 | 12 | cultivate weeds | 19 | | | | | | | | | | |
| D,N,W | 4 | 13 | herbicide application (sprayer) | 11 | | | 3 | Aatrex (Atrazine) | 2.24 | 2.00 | | | | |
| D,N,W | 4 | 13 | herbicide application (sprayer) | 11 | | | 194 | Prowl (Pendimethalin) | 2.31 | 2.06 | | | | |
| D,N,W | 4 | 14 | rebuild borders | 80 | | | | | | | | | | |
| D,N,W | 4 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D | 5 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 32 | Banvel (Dicambra Soluble Salt) | 0.56 | 0.50 | | | | |
| D,N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 204 | Roundup (Glyphosate Amine) | 2.24 | 2.00 | | | | |
| D,N,W | 5 | 20 | spot spray or aerial application of herbicides | 11 | | | 109 | Evik (Ametryn) | 1.792 | 1.60 | | . | | |
| D,N | 5 | 22 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 6 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 7 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 7 | 14 | rebuild borders | 80 | | | | | | | | | | |
| D,N | 7 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 8 | 1 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N | 8 | 15 | furrow irrigation | 72 | 152.4 | 6 | | | | | | | | |
| D,N,W | 12 | 3 | knock down borders (pre-harvest preparation) | 77 | | | | | | | | | | |
| D,N,W | 12 | 3 | harrow turnrows (pre-harvest preparation) | 25 | | | | | | | | | | |
| D,N,W | 1 | 6 | burn & harvest | 53 | | | | | | | | | | |

Changes in irrigations due to rainfall conditions
Under normal rainfall conditions (denoted with N),
Eight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop
During wet years (denoted with W),
Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop
During dry years (denoted with D),
Ten irrigations of 6" each supply 60" of irrigation water at 2/3 efficiency = 40" of water supplied to crop

Three herbicide applications (1/20, 4/13, and 5/20)

** Fertilizer application rate depends on ratoon cycle
1st Year Ratoon Cane
100 lbs/ac N (112.09 kg/ha)
2nd Year Ratoon Cane
140 lbs/ac N (156.93 kg/ha)
3rd - 5th Year Ratoon Cane
150 lbs/ac N (168.14 kg/ha)

# ιood Irrigated Citrus (Level Border Irrigation) - Baseline BMP, Current Conditions

| D Dry year<br>Normal year<br>W Wet year | Irrigated Citrus - EPIC Crop # in USDACROP.DAT = 83<br>**Non-Temik Program**, 100% trunk-to-trunk herbicide program | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 11 | 15 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| N,W | 2 | 10 | Border Ditching, forming border in preparation for flood irrigation | 82 | | | | | | | | | | |
| N,W | 2 | 15 | Fertilizer application (Ammonium Sulfate, 21-0-0,Fert. #68) | 10 | | | | | | | * | * | | |
| | 2 | 20 | **Flood Irrigation** | 72 | 127 | 5 | | | | | | | | |
| N,W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| N,W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hyvar X (bromacil) | 3.14 | 2.80 | | | | |
| N,W | 3 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| N | 3 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| N,W | 4 | 15 | Apply miticide, sprayer | 11 | | | 262 | Vendex (Fenbutatin oxide) | 1.12 | 1.00 | | | | |
| N,W | 4 | 15 | Apply fungicide, sprayer | 11 | | | 272 | Kocide (Copper hydroxide) | 4.31 | 3.85 | | | | |
| N,W | 4 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| N,W | 6 | 20 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 0.28 | 0.25 | | | | |
| N,W | 6 | 20 | Apply miticide, sprayer | 11 | | | 267 | Vydate (Oxamyl) | 0.21 | 0.19 | | | | |
| N,W | 6 | 20 | Apply citrus spray oil | 11 | | | 265 | Petroleum Spray Oil | 4.48 | 4.00 | | | | |
| N,W | 6 | 20 | Apply fungicide, sprayer | 11 | | | 272 | Kocide (Copper hydroxide) | 4.31 | 3.85 | | | | |
| N,W | 6 | 25 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| N,W | 7 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| N,W | 8 | 15 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| N,W | 8 | 15 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hyvar X (bromacil) | 3.14 | 2.80 | | | | |
| N,W | 8 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| N,W | 8 | 15 | Apply scalicide | 11 | | | 145 | Lorsban (Chlorpyrifos) | 2.24 | 2.00 | | | | |
| N,W | 8 | 15 | Apply miticide, sprayer | 11 | | | 133 | Kelthane (Dicofol) | 2.24 | 2.00 | | | | |
| N,W | 8 | 15 | Apply fungicide, sprayer | 11 | | | 39 | Benlate (Benomyl) | 1.79 | 1.60 | | | | |
| N,W | 10 | 5 | Harvest - Ring Pick | 50 | | | | | | | | | | |

*...ges in pesticide applications or irrigations due to rainfall conditions*

...der normal rainfall conditions: five irrigations (Denoted with N) of 5" each supply 25" of irrigation water at 95% efficiency = 24" of water supplied to crop
... years: four irrigations (Denoted with W) of 5" each supply 20" of irrigation water at 95% efficiency = 19" of water supplied to crop
... dry years: six irrigations (Denoted with D) of 5" each supply 30" of irrigation water at 95% efficiency = 29" of water supplied to crop
*...icide Applications* (3 Applications/year)
...ing application (3/15) of 2 selective herbicides and a contact post-emergent herbicide
...in early summer (6/20) and again in late summer (8/15)
*...icide/Miticide/Fungicide Applications* (3 applications)
...ing application (4/15) of miticide (Vendex) and fungicide (Kocide 101 for control of melanose)
...mer (6/20) application of miticide (Vydate), spray oil and fungicide (Kocide)
... Summer (8/15) application of miticide (Kelthane), scalicide (Lorsban) and fungicide (Benlate)

*Fertilizer Application Rates depend on tree age

| Tree Age | Fertilizer Application Rates | | | Nitrogen Rates | |
|---|---|---|---|---|---|
| | One Appl kg/ha | Split Appl. (kg/ha) 2/3 | 1/3 | Nitrogen lb/ac | kg/ha |
| 1 yr | 186.7 | 124.4 | 62.2 | 35 | 39.2 |
| 2 yr | 266.7 | 177.8 | 88.9 | 50 | 56.0 |
| 3 yr | 400.0 | 266.7 | 133.3 | 75 | 84.0 |
| 4 yr | 533.3 | 355.6 | 177.8 | 100 | 112.0 |
| 5 yr | 560.0 | 373.3 | 186.7 | 105 | 117.6 |
| 6 yr | 586.7 | 391.1 | 195.6 | 110 | 123.2 |
| 7 yr | 613.3 | 408.9 | 204.4 | 115 | 128.8 |
| 8 yr | 666.7 | 444.4 | 222.2 | 125 | 140.0 |
| 9 yr | 746.7 | 497.8 | 248.9 | 140 | 156.8 |
| 10+ yr | 800.0 | 533.3 | 266.7 | 150 | 168.0 |

## Flood Irrigated Citrus (Level Border Irrigation) - Baseline BMP, Current Conditions

| D=Dry year N=Normal year W=Wet year | Irrigated Citrus - EPIC Crop # in USDACROP.DAT = 83 **Temik Program**, 100% trunk-to-trunk herbicide program | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| D.N.W | 11 | 15 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 2 | 10 | Border Ditching, forming border in preparation for flood irrigation | 82 | | | | | | | | | | |
| D.N.W | 2 | 15 | Fertilizer application (Ammonium Sulfate, 21-0-0, Fert #68) | 10 | | | | | | | * | * | | |
| D | 2 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| D.N.W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hivar X (Bromacil) | 3.14 | 2.80 | | | | |
| D.N.W | 3 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| D.N | 3 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 4 | 1 | Apply pesticide, sprayer | 11 | | | 236 | Temik (Aldicarb) | 5.54 | 4.95 | | | | |
| D.N.W | 4 | 15 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 6 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 0.28 | 0.25 | | | | |
| D.N.W | 6 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 7 | 20 | Flood Irrigation | 72 | 127 | 5 | | | | | | | | |
| D.N.W | 8 | 15 | Apply scalicide | 11 | | | 145 | Lorsban (Chlorpyrifos) | 2.24 | 2.00 | | | | |
| D.N.W | 8 | 15 | Apply fungicide | 11 | | | 39 | Benlate (Benomyl) | 1.79 | 1.60 | | | | |
| D.N.W | 8 | 15 | Apply miticide, sprayer | 11 | | | 133 | Kelthane (Dicofol) | 2.24 | 2.00 | | | | |
| D.N.W | 8 | 15 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| D.N.W | 8 | 15 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hyvar X (bromacil) | 3.14 | 2.80 | | | | |
| D.N.W | 8 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| D.N.W | 10 | 5 | Harvest - Ring Pick | 50 | | | | | | | | | | |

*Changes in pesticide applications or irrigations due to rainfall conditions*
Under normal rainfall conditions, five irrigations (Denoted with N) of 5" each supply 25" of irrigation water at 95% efficiency = 24" of water supplied to crop
During wet years, four irrigations (Denoted with W) of 5" each supply 20" of irrigation water at 95% efficiency = 19" of water supplied to crop
During dry years, six irrigations (Denoted with D) of 5" each supply 30" of irrigation water at 95% efficiency = 29" of water supplied to crop
*Herbicide Applications* (3 Applications/year)
Spring application (3/15) of 2 selective herbicides and a contact post-emergent herbicide
Treat again in early summer (6/15) and again in late summer (8/15)
*Scalicide/Miticide/Fungicide Applications under Temik Program* (2 applications/yr)
Single application of Temik in spring (4/1) at 30 lb/acre
Late Summer (8/15) application of miticide (Kelthane), scalicide (Lorsban) and fungicide (Benlate)

*Fertilizer Application Rates depend on tree age

| Tree Age | Fertilizer Application Rates | | | Nitrogen Rates | |
|---|---|---|---|---|---|
| | One Appl kg/ha | Split Appl. (kg/ha) 2/3 | 1/3 | Nitrogen lb/ac | kg/ha |
| 1 yr | 186.7 | 124.4 | 62.2 | 35 | 39.2 |
| 2 yr | 266.7 | 177.8 | 88.9 | 50 | 56.0 |
| 3 yr | 400.0 | 266.7 | 133.3 | 75 | 84.0 |
| 4 yr | 533.3 | 355.6 | 177.8 | 100 | 112.0 |
| 5 yr | 560.0 | 373.3 | 186.7 | 105 | 117.6 |
| 6 yr | 586.7 | 391.1 | 195.6 | 110 | 123.2 |
| 7 yr | 613.3 | 408.9 | 204.4 | 115 | 128.8 |
| 8 yr | 666.7 | 444.4 | 222.2 | 125 | 140.0 |
| 9 yr | 746.7 | 497.8 | 248.9 | 140 | 156.8 |
| 10+ yr | 800.0 | 533.3 | 266.7 | 150 | 168.0 |

# Micro-Spray Irrigated Citrus - BMP #4, Improved Irrigation Technology

| D - Dry year<br>N - Normal year<br>W - Wet year | Irrigated Citrus - EPIC Crop # in USDACROP.DAT = 83<br>Temik Program, 100% trunk-to-trunk herbicide program | | | EPIC Tillage # | Irrigation Volume | | EPIC Pesticide # | Pesticide Trade Name (Common Name) | Pesticide Application Rates (Active Ingredient) | | N Application Rates | | P Application Rates (as P) $P_2O_5 = 2.27P$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Month* | *Day* | *Operation* | | *mm* | *in.* | | | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* | *kg/ha* | *lb/ac* |
| N,W | 10 | 7 | Weekly Irrigation | 72 | 23.8 | 0.94 | | | | | | | | |
| N,W | 10 | 21 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 23.8 | 0.94 | | | | | * | * | | |
| N,W | 11 | 4 | Weekly Irrigation | 72 | 23.8 | 0.94 | | | | | | | | |
| N,W | 11 | 18 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 23.8 | 0.94 | | | | | * | * | | |
| N,W | 2 | 15 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 17.3 | 0.68 | | | | | * | * | | |
| N,W | 2 | 22 | Weekly Irrigation | 72 | 17.3 | 0.68 | | | | | | | | |
| N,W | 3 | 1 | Weekly Irrigation | 72 | 17.3 | 0.68 | | | | | | | | |
| N,W | 3 | 8 | Weekly Irrigation | 72 | 17.3 | 0.68 | | | | | | | | |
| N,W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| N,W | 3 | 15 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hyvar X (bromacil) | 3.14 | 2.80 | | | | |
| N,W | 3 | 15 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| N,W | 3 | 15 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 17.3 | 0.68 | | | | | * | * | | |
| N,W | 3 | 22 | Weekly Irrigation | 72 | 17.3 | 0.68 | | | | | | | | |
| N,W | 3 | 29 | Weekly Irrigation | 72 | 17.3 | 0.68 | | | | | | | | |
| N,W | 4 | 1 | Apply pesticide, sprayer | 11 | | | 236 | Temik (Aldicarb) | 5.04 | 4.95 | | | | |
| N,W | 4 | 5 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 4 | 12 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 19.5 | 0.77 | | | | | * | * | | |
| N,W | 4 | 15 | Inject selective herbicide (preemergent) | 11 | | | 223 | Surflan (Oryzalin) | 2.24 | 2.00 | | | | |
| N,W | 4 | 19 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 4 | 26 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 5 | 2 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 5 | 9 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 5 | 16 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 19.5 | 0.77 | | | | | * | * | | |
| N,W | 5 | 23 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 5 | 30 | Weekly Irrigation | 72 | 19.5 | 0.77 | | | | | | | | |
| N,W | 6 | 6 | Weekly Irrigation | 72 | 21.7 | 0.85 | | | | | | | | |
| N,W | 6 | 13 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 21.7 | 0.85 | | | | | | | | |
| N,W | 6 | 19 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 0.28 | 0.25 | | | | |
| N,W | 6 | 20 | Weekly Irrigation | 72 | 21.7 | 0.85 | | | | | | | | |
| N,W | 6 | 27 | Weekly Irrigation | 72 | 21.7 | 0.85 | | | | | | | | |
| N,W | 7 | 1 | Apply citrus spray oil | 11 | | | 265 | Petroleum Spray Oil | 3.36 | 4.00 | | | | |
| N,W | 7 | 1 | Apply miticide, sprayer | 11 | | | 262 | Vendex (Fenbutatin oxide) | 1.12 | 1.00 | | | | |
| N,W | 7 | 1 | Apply fungicide, sprayer | 11 | | | 272 | Kocide (Copper hydroxide) | 4.32 | 3.85 | | | | |
| N,W | 7 | 4 | Weekly Irrigation | 72 | 23.8 | 0.94 | | | | | | | | |
| N,W | 7 | 11 | Weekly Irrigation | 72 | 23.8 | 0.94 | | | | | | | | |
| N,W | 7 | 18 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 23.8 | 0.94 | | | | | * | * | | |
| N,W | 7 | 25 | Weekly Irrigation | 72 | 23.8 | 0.94 | | | | | | | | |
| N,W | 8 | 1 | Weekly Irrigation | 72 | 26 | 1.03 | | | | | | | | |
| N,W | 8 | 8 | Weekly Irrigation | 72 | 26 | 1.03 | | | | | | | | |
| N,W | 8 | 12 | Apply selective herbicide (preemergent) | 11 | | | 192 | Princep (Simazine) | 3.53 | 3.15 | | | | |
| N,W | 8 | 12 | Apply selective herbicide (preemergent) | 11 | | | 126 | Hyvar X (bromacil) | 3.14 | 2.80 | | | | |
| N,W | 8 | 12 | Apply contact herbicide | 11 | | | 204 | Roundup (Glyphosate isopropyl amine salt) | 1.79 | 1.60 | | | | |
| N,W | 8 | 15 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 26 | 1.03 | | | | | * | * | | |
| N,W | 8 | 20 | Apply scalicide | 11 | | | 145 | Lorsban (Chlorpyrifos) | 2.24 | 2.00 | | | | |
| N,W | 8 | 20 | Apply miticide, sprayer | 11 | | | 133 | Kelthane (Dicofol) | 2.24 | 2.00 | | | | |
| N,W | 8 | 20 | Apply fungicide, sprayer | 11 | | | 39 | Benlate (Benomyl) | 1.79 | 1.60 | | | | |
| N,W | 8 | 22 | Weekly Irrigation/Fertilizer application (N32, 32-0-0) | 72/13 | 26 | 1.03 | | | | | * | * | | |
| N,W | 9 | 15 | Inject selective herbicide (preemergent) | 11 | | | 110 | Solicam (Norflurazon) | 2.24 | 2.00 | | | | |
| N,W | 10 | 5 | Harvest - Ring Pick | 48 | | | | | | | | | | |

| Tree Age | *Monthly Application Rates* N | N | Fert. Rate |
|---|---|---|---|
| | lb/acre | kg/ha | kg/ha |
| 1 yr | 2.8 | 3.136 | 9.80 |
| 2 yr | 4 | 4.48 | 14.00 |
| 3 yr | 6 | 6.72 | 21.00 |
| 4 yr | 8 | 8.96 | 28.00 |
| 5 yr | 8.4 | 9.408 | 29.40 |
| 6 yr | 8.8 | 9.856 | 30.80 |
| 7 yr | 9.2 | 10.3 | 32.20 |
| 8 yr | 10 | 11.2 | 35.00 |
| 9 yr | 11.2 | 12.54 | 39.20 |
| 10+ yr | 12 | 13.44 | 42.00 |

*...bicide Applications* (5 Applications/year)
... less leachable herbicides such as Surflan and Solicam
...at in the spring (3/15 and 4/15), early summer (6/19), late summer (8/12), and early fall (9/15)
*...icide/Miticide/Fungicide Applications under Temik Program* (3 applications/yr)
...le application of Temik in spring (4/1) at 30 lb/acre
... (7/1) application of miticide (Vendex), spray oil and fungicide (Kocide)
... Summer (8/20) application of miticide (Kelthane), scalicide (Lorsban) and fungicide (Benlate)

* Fertilizer Application Rates depend on tree age
Liquid Fertilizer (80% of that applied to flood irrigated groves) applied monthly (10 months)
N32 applied with irrigation water monthly (10 months)

# APPENDIX I

## Assumptions Used in Modeling Analysis

1. Non-row crop areas consisting of perennial vegetation including native pastures and rangeland (native grasses, trees and shrubs) do not utilize subsurface drains or land leveling.

2. Dryland cropping systems (cotton rotated with either grain sorghum or corn) do not utilize subsurface drainage systems.

3. Most of the irrigated cropland acreage (cotton in rotation with either grain sorghum or corn, sugarcane rotated with cotton) have subsurface drains installed except for the very heavy clays such as Grulla clay and Harlingen clay.

   *Based on assumptions 1, 2 and 3, it was calculated that 44,667 acres, approximately 72 percent of the irrigated cropland in the study area have subsurface drainage systems installed.*

4. All of the irrigated citrus acreage (regardless of soil type) has been leveled.

5. Approximately 80 percent of the cropland in the study area, has had irrigation land leveling [or precision land forming of dryland areas] implemented as a management practice for improved distribution of irrigation and rain water.

6. The land slopes assumed for areas which <u>have been leveled</u>.

   Citrus - 0 % slope (used 0.0001)

   All other cropland areas - (0.075'/100') = 0.075 % slope (used 0.00075)

7. The natural slopes for cropland areas which <u>have not been leveled</u> were assumed to be:

   Soil Group 1 = 0.58 %

   Soil Group 2 = 0.50 %

   Soil Group 3 = 0.55 %

   Soil Group 4 = 0.27 %

   Soil Group 5 = 0.65 %

   Soil Group 6 = 0.71 %

   These are based on area weighted slopes calculated for the study area using slopes designated in the Cameron County Soil Survey. In some instances, the specified slopes were adjusted based on the professional judgment of local NRCS personnel.

8. Vegetable crops were not considered in the modeling analysis. Only 25,090 acres of vegetable crops were grown in Cameron County in 1989 (TWDB, 1991), comprising less than 10% of the cropland acreage countywide. Vegetable crops are not prevalent in the Arroyo Colorado study area due to the soil types occurring in the area.

9. Approximately 10-15% of the cotton in the study area is rotated with corn. The majority (85-90%) of the cotton is rotated with grain sorghum. Assumption: 15% of the cotton rotated with corn and 85% rotated with grain sorghum.

10. The majority (>90%) of the cotton grown in the area (both dryland and irrigated) is picker cotton. Less than 10% of the cotton is stripper cotton. For the modeling analysis, it was assumed that all of the cotton grown in the study area was picker cotton.

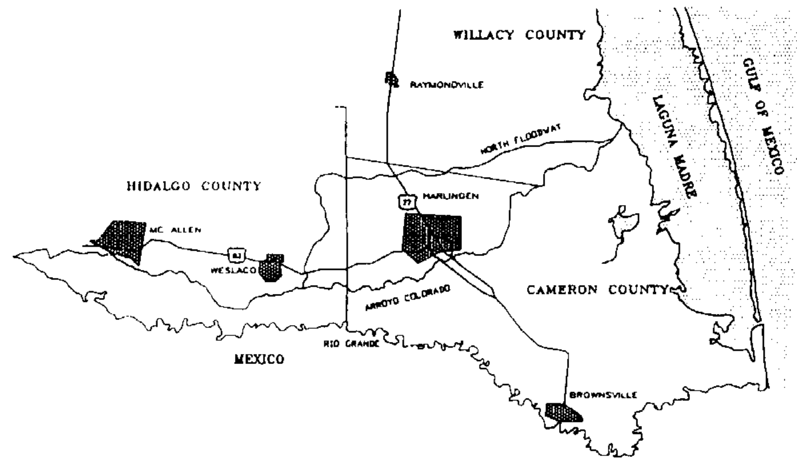
# APPENDIX G

## Registration Lists and Materials Prepared for Seminars and Workshops

## PEAKERS

| | |
|---|---|
| arrie Bausch | Student Technician, Agricultural Engineering Department, Texas Agricultural Extension Service, College Station |
| i. Guy Fipps | Associate Professor and Extension Agricultural Engineer, Texas Agricultural Extension Service, College Station |
| an Flowers | Senior Research Associate, Texas Institute for Applied Environmental Research, Stephenville |
| ny Gonzales | Conservationist, Natural Resources Conservation Service, San Benito |
| rry Lockamy | Cameron County Extension Agent, San Benito |
| lan Moore | Agricultural Engineer, Natural Resources Conservation Service, San Benito |
| nn Pardee | USEPA Project Manager - Region 6, U.S. Environmental Protection Agency, Dallas |
| . Bryan Shaw | Assistant Professor and Extension Agricultural Engineer, Texas Agricultural Extension Service, College Station |
| avid W. Smith | Extension Associate, Texas Agricultural Extension Service, College Station |
| . Stormy Sparks | Associate Professor and Extension Entomologist, Texas Agricultural Extension Service, Weslaco |
| ron Spoonts | Texas State Soil and Water Conservation Board, Temple |

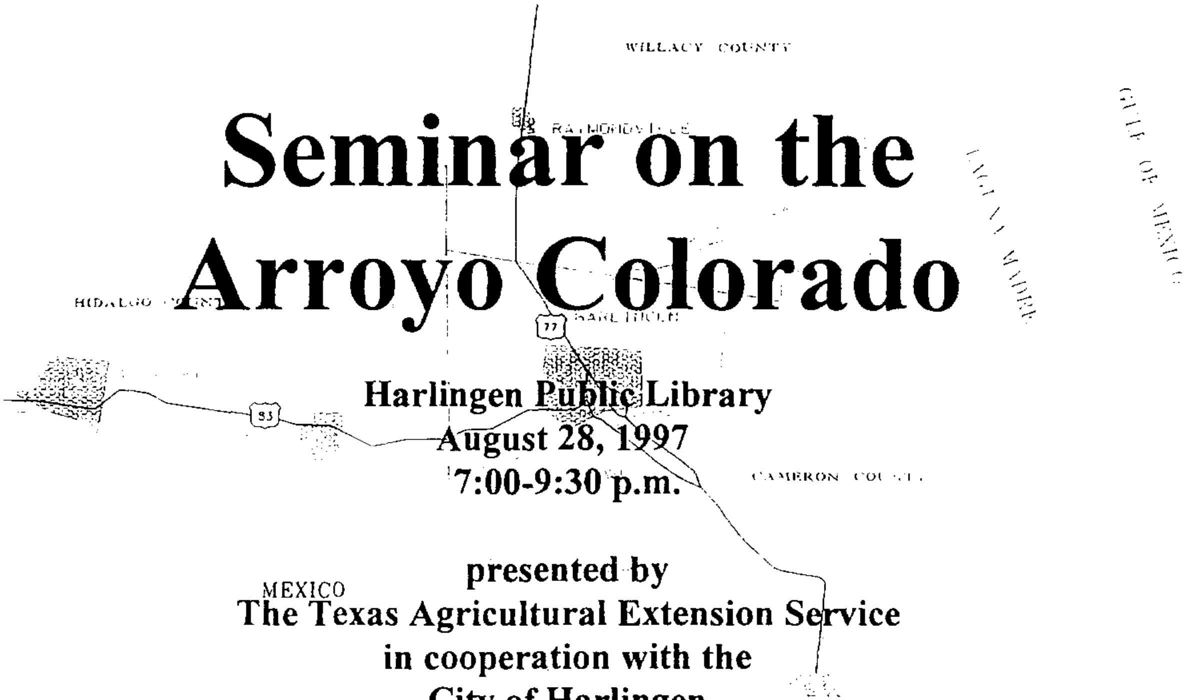
# Seminar on the Arroyo Colorado




**Harlingen Public Library**
**August 28, 1997**
**7:00-9:30 p.m.**

**presented by**
**The Texas Agricultural Extension Service**
**in cooperation with the**
**City of Harlingen**

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission




# Seminar on the Arroyo Colorado

**Harlingen Public Library**
**August 28, 1997**
**7:00-9:30 p.m.**

**presented by**
**The Texas Agricultural Extension Service**
**in cooperation with the**
**City of Harlingen**

**Description**
The Seminar will present the results of the multi-agency project: ***Non-point Source Pollution Prevention in the Arroyo Colorado Watershed.*** The project was funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). Cooperating agencies included the Natural Resources Conservation Service (NRCS), the Southmost Soil and Water Conservation District, the Texas Institute for Applied Environmental Research (TIAER), and the Texas Agricultural Extension Service (TAEX).

**Program**

| | |
|---|---|
| 7:00 p.m. | **Welcome, Project Overview** |
| | T. Lockamy, G. Fipps, B. Spoonts, L. Pardee (invited) |
| 7:30 | **The Arroyo Colorado Water Quality Data Base - What do we know?** |
| | C. Bausch, G. Fipps |
| 8:00 | **Demonstration Sites and Results** |
| | T. Gonzales, A. Moore |
| 8:30 | **Best Management Practices - Modeling and Projected Benefits** |
| | J. Flowers |
| 9:00 | **Educational Program Outcomes** |
| | G. Fipps, D. Smith, S. Sparks, B. Shaw |
| 9:30 | **Adjourn** |

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

Texas Agricultural Extension Service
The Texas A&M University System

August 13, 1997

RECEIVED
SEP 18 1997
TEXAS STATE SOIL AND
WATER CONSERVATION BOARD

RE: Local Advisory Committee - Arroyo Colorado Project

Dear

Several years ago, you were asked by the then Texas Water Commission (now the Texas Natural Resource Conservation Commission) and the Texas State Soil and Water Conservation Board (TSSWCB) to serve on the Local Advisory Committee for the Section 319 Project: *Non-point Source Prevention in the Arroyo Colorado Watershed.* You may be aware that this project officially ends on August 31, 1997.

The Texas Agricultural Extension Service invites you to participate in a **Seminar on the Arroyo Colorado** to be held on August 28, 7:00 p.m. to 9:30 p.m. at the Harlingen City Library (see enclosed flyer). For the Seminar, we have asked representatives from all participating agencies to provide a brief overview of their roles in the project and the results of their efforts.

Please join us for this informative program.

Sincerely,

Guy Fipps
Associate Professor *and*
Extension Agricultural Engineer

enclosure

# Seminar on the Arroyo Colorado

Harlingen Public Library
August 28, 1997
7:00 pm - 9:30 pm

| Name | Company | Address | City | Zip Code | Phone Number |
|---|---|---|---|---|---|
| [illegible] P. Oliver | Rep. Valley Sportsman Club | Rt 1 Box 320 | San Benito | 78586 | 399-3867 |
| Gordon Dix | Rep. Valley Sports Club | 1113 E. Polk | Harl. | 78550 | 423-4749 |
| John Norman | Tx. Ag. Ext.-Serv. | 2401 E. Highway 83 | Weslaco | 78596 | 968-5581 |
| Tony Gonzales | USDA NRCS | 2315 W. Expw 83 | San Benito | 78586 | 399-2522 |
| Alan [illegible] | USDA [illegible] | 2315 W. Expw 83 [illegible] 103 | San Benito | 78586 | 399-2522 |
| [illegible] | [illegible] | [illegible] | Temple | 76501 | 254 [illegible] |
| [illegible] | [illegible] | P.O. [illegible] | Santa Rosa | 78593 | 636-1[illegible] |
| LEN PARDEE | EPA | 1445 ROSS DALLAS 75202 | | | 214 665 8086 |
| Kelvin Moore | TNRCC | | Austin | 78753 | 512 239 2272 |
| Bo Spoonts | TSSWCB | 311 N 5th Temp | Temple | 76501 | 254 773 2250 |
| [illegible] | [illegible] | 1[illegible] Jefferson | Harlingen | 78550 | 956 421-5341 |
| David [illegible] | Valley Morning Star | | Harlingen | | 956 430-6200 |
| Eduardo A Campirano | Valley [illegible] | [illegible] | Harlingen | 78[illegible] | 956 [illegible] |
| Mr. H J [illegible] | Garrett Farms Inc | Rt 3 Box 171 Hgn | Hgn | 78552 | 956 423-0569 |

sented by: Cameron County Crops Committee

Committed to the future of agriculture.

perating Sponsors:

Cameron County Extension Office
Natural Resource Conservation Service
Southern Regional Sustainable Agricultural
Research and Education Program
Southmost Soil & Water Conservation District
Texas Agricultural Extension Service
USDA-Agricultural Research Service
U.S.E.P.A. - Arroyo Colorado Project

**Cameron County Field Crops Committee**

# 2nd Annual

## No-Till Field Day & Farm Show
**Rangerville Coop Gin**
**April 30, 1997**
**9:00 a.m. - Noon**
**Lunch Provided**

**3 CEU's and Door Prizes**

Committed to the future of agriculture.

# Texas Agricultural Extension Service

The Texas A&M University System

## 2nd Annual
## No - Till Field Day

Rangerville Coop Gin

**April 30, 1997**

**9:00 - Noon**

## Presented By: CAMERON COUNTY FIELD CROP COMMITTEE

FEATURING:

PLANTING EQUIPMENT FOR CONSERVATION TILLAGE
COULTERS, RESIDUE FINGERS, RIDGE RUNNER

CATOLACCUS AND CONTROL OF THE BOLL WEEVIL

CROP CULTIVATION IN HIGH RESIDUE CONDITIONS

FERTILIZER PLACEMENT FOR CONSERVATION TILLAGE

HOODED SPRAYERS FOR CONSERVATION TILLAGE

OTHER CONSERVATION TILLAGE EQUIPMENT

| | |
|---|---|
| STALK PULLER | FERTILIZER APPLICATORS |
| SHREDDER | CULTIVATORS |
| PLANTERS | |

CHEMICAL PRECISION APPLICATORS AND SAFETY CONCERNS

IMPROVING FERTILIZER EFFICIENCY THROUGH BEST
MANAGEMENT PRACTICES

## EQUIPMENT DISPLAY & FIELD DEMONSTRATION

TECHNICAL ASSISTANCE PROVIDED BY:
TEXAS AGRICULTURAL EXTENSION SERVICE
NATURAL RESOURCE CONSERVATION SERVICE
USDA- AGRICULTURAL RESEARCH SERVICE

**LUNCH PROVIDED** **2 CEU'S AVAILABLE**

# RECERTIFICATI ON CREDITS ATTENDANCE RECORD

Mailed 5-5-97 to TDA

| Activity or Event | Date |
|---|---|
| NO TILL FIELD DAY | APRIL 30, 1997 |

| Course Number | General | | L&R | | IPM | | Drift | | Total |
|---|---|---|---|---|---|---|---|---|---|
| 8061 | 1 | + | 0 | + | 1 | + | 1 | = | 3 hrs. |

PRINT CLEARLY

| | Name | TDA License or Social Security | Address | City | Zip |
|---|---|---|---|---|---|
| 1 | Terry A. Lockamy | 121149 | 650 E. Hwy 77- | San Benito, Tx | 78586 |
| 2 | Bill McMurray | 453-46-9964 | Rt. 1 Box 335 | San Benito, Tx | 78586 |
| 3 | Randy McMurray | 463-17-7197 | Rt. 1 Box 335M | San Benito, Tx | 78586 |
| 4 | Chris Anzaldua | 14530870 | 1826 W. Jefferson, | Harlingen, Tx | 78550 |
| 5 | Chuck McCutchen | R-151003 | Rt. 2, Box 120 | Mercedes, Tx | 78570 |
| 6 | Bob Bierman | 135963 | 1327 Theiss Mail Rd. | Spring, Tx | 77379 |
| 7 | Juan Arturo Salazar | 142711 | Rt. 4, Box 107 | San Benito, Tx | 78586 |
| 8 | Dennis Burrell | 463-76-1168 | P.O. Box 247 | D'Hanis, Tx | 78850 |
| 9 | Scott Campbell | 168178 | 6516 N. 35th | McAllen, Tx | 78504 |
| 10 | Eugene L. Ashley | 185317 | Rt. 1 Box 268 | Harlingen , Tx | 78552 |
| 11 | Randall S. Ashley | 128624 | 618 Pinehurst Blvd. | Harlingen, Tx | 78552 |
| 12 | Glenn R. Sturm | 459-02-0842 | 1444 Cr. 341 | Hondo, Tx | 78861-6812 |
| 13 | Paul Bauer | 455-90-0077 | 2315 Exp 83 | San Benito, Tx | 78586 |
| 14 | Lynn Angell | 126018 | 26211 Hutymn Glen | Boerne, Tx | 78006 |

| | | | | | |
|---|---|---|---|---|---|
| 40 | Kenneth Buford | 464-04-2378 | 2514 S. "I" Rd. | Edinburg, Tx | 78539 |
| 41 | Eloy Corona | 463-29-1196 | P.O. Box 531090 | Harlingen, Tx | 78553 |
| 42 | Eduardo Mendez | 466-83-1605 | 1826 W. Jefferson | Harlingen, Tx | 78550 |
| 43 | Ruben Vento | 449-06-6613 | Rt. 1, Box 53 | La Feria, Tx | 78559 |
| 44 | Steve Frazier | 122963 | 2313 N. Parkwood | Harlingen, Tx | 78550 |
| 45 | H.J. Garrett | 526-10-3910 | Rt. 3 Box 171 | Harlingen, Tx | 78550 |
| 46 | Joel Saldivar | 210884 | Rt. 2 Box 376 | Lyford, Tx | 78569 |
| 47 | Bailey H. Dunlap, Jr. | 185392 | P.O. Box 458 | La Feria, Tx | 78559 |
| 48 | Ed Gage | 122533 | P.O. Box 63447 | Pipe Creek, Tx | |
| 49 | Noe G. Garza | 133566 | 2514 S. "I" Rd. Ste 2 | Edinburg, Tx | 78539 |
| 50 | Terry W. Mize | 127069 | 7502 Dryfuss | Amarillo, Tx | |
| 51 | Charles Stichler | 212487 | Box 1849 | Uvalde, Tx | 78802 |
| 52 | Juan Leija | 126713 | 413 N. Kenyon Rd. | Edinburg, Tx | 78539 |
| 53 | Juan M. Pena | 133598 | P.O. Box 195 | Raymondville, Tx | 78580 |
| 54 | Norman Ruzoff | 030-26-3340 | P.O. Drawer A | Santa Rosa, Tx | 78593 |
| 55 | William Goad | P99-64436 | 775 E. Hudson Rd. | San Benito, Tx | 78586 |
| 56 | Peter Bachman | 185646 | Rt.2, Box 112A | Alamo, Tx | 78516 |
| 57 | Ramon Reza | 133604 | P.O. Box 519 | Sebastian, Tx | |
| 58 | Tony Prado | P-99-64842 | Rt. 1 Box 100-C | Santa Rosa, Tx | 78593 |
| 59 | Don Jaeger | 471-62-1866 | Rt. 1, Box 221 | Primera, Tx | |
| 60 | Larry Allen | 134502 | 1616 Ave. M | Hondo, Tx | 78861 |
| 61 | Jack N. Sutter | 455-28-9989 | 4104 Old Port Isabel Rd. | Brownsville, Tx | 78521 |
| 62 | Joe Lane | 467-18-5860 | Rt. 3, Box 429 | Harlingen, Tx | 78550 |
| 63 | James L. Cantrell | 453-46-5396 | RR8 Box 58 | San Benito, Tx | 78586 |
| 64 | Fred G. Karle | 121668 | Rt.2, Box 2232 | McAllen, Tx | 78504 |
| 65 | James Smart | 167778 | 2002 E. 18th | Weslaco, Tx | 78596 |

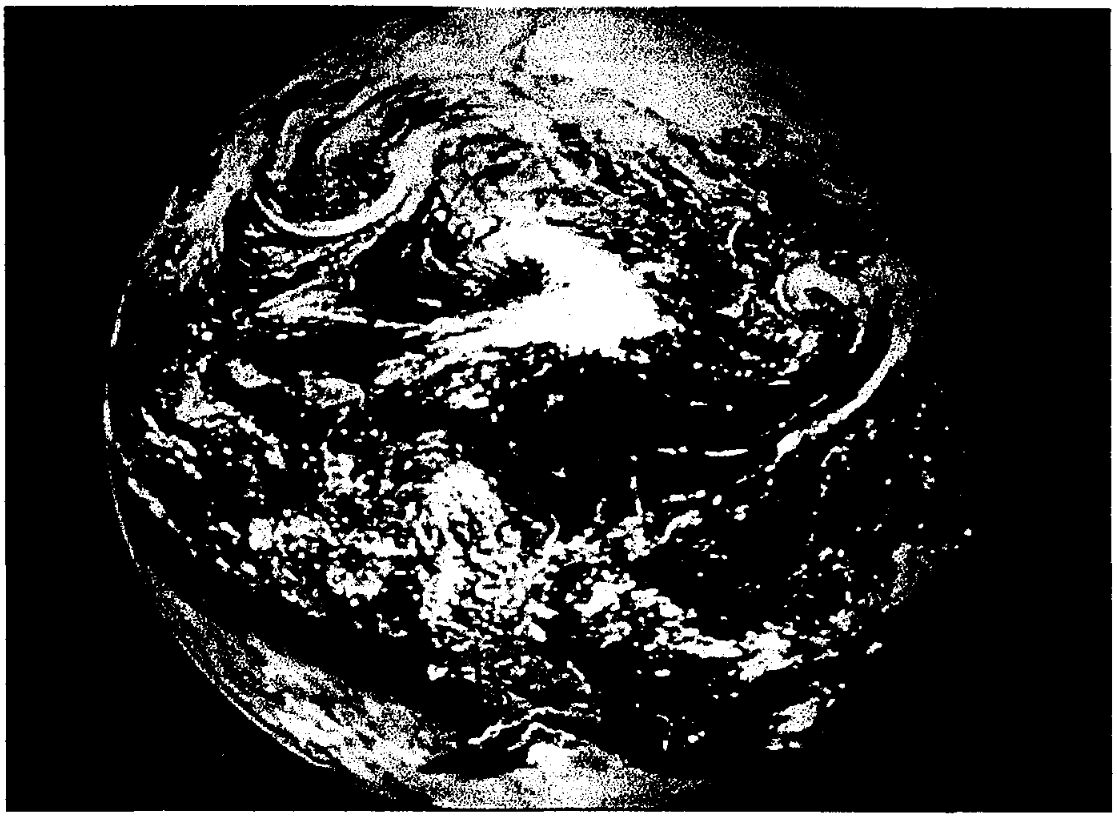
| | | | | | |
|---|---|---|---|---|---|
| 92 | Jaime Luna | 204757 | Rt. 1 Box 198-E | La Feria, Tx | 78559 |
| 93 | Jesus Vasquez | 1193413 | P.O. Box 5109 | Brownsville, Tx | 78523 |
| 94 | Miguel Bustamante | 198099 | Rt. 2, Box 55 | Mercedes, Tx | 78570 |
| 95 | Mike Black | 461-64-3610 | Box 366 | Agua Dulce, Tx | |
| 96 | S. T. Minor | 456-62-7192 | | San Benito, Tx | 78586 |
| 97 | Michael Yeary | 194516 | P.O. Box 278 | Progreso, Tx | 78579 |
| 98 | Craig Bookout | 187692 | Rt. 1 Box 43-B | Santa Rosa, Tx | 78593 |
| 99 | Heath Harris | 461-61-3219 | 185 Lakeview S. | San Benito, Tx | 78586 |
| 100 | Don Sugarek | 463-74-5629 | Rt. 1, Box 237 | Beeville, Tx | |
| 101 | Andy Scott | 122475 | Rt. 1 Box 324 | Monte Alto, Tx | 78538 |
| 102 | Victor H. Valladares | 207617 | Rt. 1, Box 521 | Weslaco, Tx | 78596 |
| 103 | Don Vogel | 454-78-5022 | Rt. 2, Box 184 | Mercedes, Tx | 78570 |
| 104 | Jim E. Brockington | 223904 | 616 Silva Dr. | Weslaco, Tx | 78596 |
| 105 | Oscar Longoria, Jr. | 134683 | 1811 N. Alamo Rd. | Edinburg, Tx | 78539 |
| 106 | Gary Mack | 133743 | 905 Travis | Harlingen, Tx | 78550 |
| 107 | Blaine M. Morrow | 457-92-2638 | P.O. Box 4797 | McAllen, Tx | 78502 |
| 108 | David L. Schertz | 322-3808620 | 1342 Butler Churn Dr. | Herndon, VA | |

| | | | | | |
|---|---|---|---|---|---|
| 21 | Joe A. Fernandez | | P.O. Box 533576 | Harlingen | 78553 |
| 22 | Les Waldrop | | P.O. Box 718 | Portland, Tx | 78374 |
| 23 | Justin Hester | | P.O. Box 658 | Temple, Tx | 76502 |
| 24 | Abel Epp | | P.O. Box 4652 | McAllen, Tx | 78504 |
| 25 | Joe Bradford | | USDA-ARS | Weslaco, Tx | 78596 |
| 26 | Susan Gray | | USDA-ARS | Weslaco, Tx | 78596 |
| 27 | Steve Roach | | Rt. 2, Box 155B | Alamo, Tx | 78516 |
| 28 | Lee Bauer | | Rt.5, Box 195 | Harlingen, Tx | 78550 |
| 29 | Jason Johnson | | 2401 E. Hwy 83 | Weslaco, Tx | 78596 |
| 30 | Troy Myers | | 4110 N. 77#7178 | Harlingen, Tx | 78552 |
| 31 | Bubba King | | RR7 Box 213Y | Edinberg, Tx | |
| 32 | Shannon Linderoth | | 301 Hesters Crossing, Sk. 130 | RoundRock,Tx | 78681 |
| 33 | Dan Crummett | | 408 S. Main Ste 3 | Stillwater, Ok | 74074 |
| 34 | Mark Seipel | | P.O. Box 358 | Colchester, Il. | |
| 35 | Tony Gonzales | | 2315 W. Expw 83 | San Benito, Tx | 78586 |
| 36 | Donald Makus | | USDA-ARS | Weslaco, Tx | 78596 |
| 37 | David W. Smith | | 306 E. Agen Dept. | College Station | 77843-2121 |
| 38 | Sam Magee | | Rt. 1 Box 381 | San Benito | 78586 |
| 39 | Ricardo Gonzalez | | 5250 Coffee Port | Brownsville | 78520 |
| 40 | Doug Sharer | | 143 Woodland Trl. | Belton, Tx | 76513 |
| 41 | Jorge Rosas | | 105 Villafranca St. | Brownsville, | 78521 |
| 42 | Guy Thomas | | | Canyon Lake | |
| 43 | M. Dailey | | 614 So. 16th | Harlingen, Tx | 78550 |

| | | | | | |
|---|---|---|---|---|---|
| 22 | Lucio Mercado G. | | Carr. M. Aleman KM 15.5 | Apodaca | N.L., Mexico |
| 23 | G. Jimenez | | | Monterrey | |
| 24 | J. Enrique Rodarte S. | | 3 ERA Cerrada de Medrida | Sinaloa | Mexico |
| 25 | Jorge Lugo | | Rio Hymaya #128-C pte. | Culiacan, Sin. | Mexico |
| 26 | Mario M. Silva | | Campo Exp. Rio Bravo | Apdo. Postal 1F2 | |
| 27 | Fernando Gonzalez G. | | | Matamoros | Tamps |
| 28 | Abel Duran | | Costa Azul | Matamoros | Tamps |
| 29 | Jaime Villarreal | | A. Obregon #3 | Matamoros | Tamps |
| 30 | Francisco de la Garza | | Calle 8 #170 | Matamoros | Tamps |
| 31 | Angel Sanchez | | Laguna Madre | Matamoros | Tamps |
| 32 | Teodoro Cantu | | Morelos 312 | Rio Bravo | Tamps |
| 33 | Pablo Flores Morales | | | Matamoros | Tamps |
| 34 | Fernando Gomez Gomez | | Francisco I. Madero #907 | Rio Bravo | Tamps |
| 35 | Luis Lovanca | | Carr. Miguel Alalman | N.L. Mexico | Tamps. |
| 36 | Jorge Luis Martinez S. | | Fislcos #140 Col. Tecro | Monterrey | N.L., Mexico |
| 37 | Miguel Ibarra | | San Lorenzo | Guadallupe | N.L., Mexico |
| 38 | Jorge Gonzalez P. | | | Monterrey | N.L., Mexico |
| 39 | Navoloto Sin | | | | Mexico |
| 40 | Rafel Dominguez Obeso | | | Sinaloa | Mexico |
| 41 | Jacobo Gaxlola Lugo | | Lago de Ipacara 3114 | Sinaloa | Mexico |
| 42 | Guillermo Gastelon | | Juan Escutia #440 | Col. Chapulte Pec | Mexico |
| 43 | Palszuglos Amod | | Montes Cirales 504 | | Mexico |

# Help Yourself, Help the Environment

Today, you are learning about the benefits of no-till and reduced tillage for improving crop yields, reducing costs and maintaining soil productivity. However, there are other benefits - like helping our environment. Conservation tillage helps reduce runoff from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including conservation tillage, and proper water and nutrient management, you will be doing your part to help protect the water quality in the Valley.



## *The Arroyo Colorado*

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

ASCE

The First International Conference on

# WATER RESOURCES ENGINEERING

and International

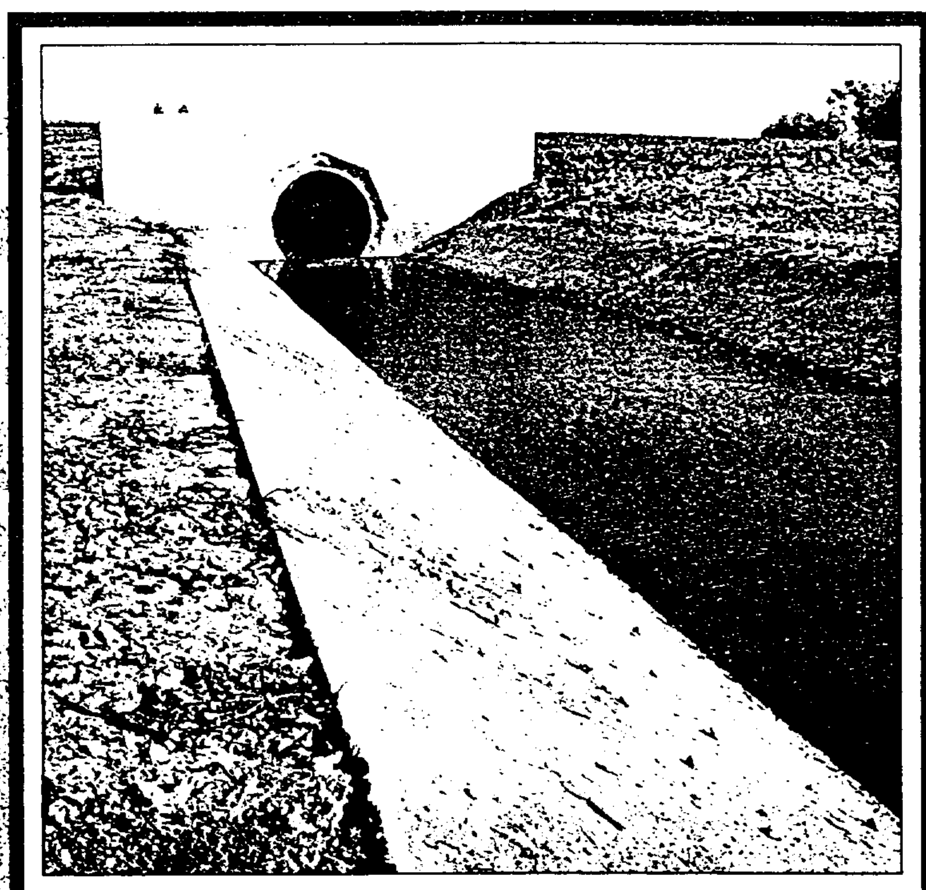
# GROUNDWATER MANAGEMENT

Symposium

# WATERSHED MANAGEMENT

Symposium

# TEXAS WATER '95



Hyatt Regency, San Antonio
San Antonio, Texas • August 14-18, 1995

**AMERICAN SOCIETY OF CIVIL ENGINEERS**

**Buffalo Bayou Erosion Control And Bank Stabilization Study:** DAVID PARKHILL, Brown&Root, Inc., Houston, TX and GREG DICIOCCIO, Harris County Flood Control District, Houston, TX,

**Application Of The Unit Hydrograph Method To The Hill Country Region Of South-Central Texas:** KELLY J. KAATZ and DAVID A. DICKERSON, HDR Engineering, Inc., Austin, TX

SESSION T 7 *Nueces*

TEXAS WATER PLANNING

*Moderator:* JOHN GROUNDS, Albert Halff & Associates, Inc., Houston, TX

**Development of Reservoir Operating Rule to Meet Bay And Estuary Needs:** STEPHEN DENSMORE, Texas Water Development Board, Austin, TX

**Urban Hydrology Information For Stormwater Management Planning In Texas:** MARSHALL E. JENNINGS, U.S. Geological Survey, Austin, TX and WILLIAM H. ESPEY, JR., RMI, Inc., Austin, TX

**Lower Colorado River Authority Water Management Plan:** QUENTIN MARTIN, Lower Colorado River Authority, Austin, TX

**Lower Colorado River Authority Clean Rivers Act Program:** KEN MANNING, Lower Colorado River Authority, Austin, TX

SESSION T 8 *Frio*

TEXAS WATER RESOURCES II

*Moderator:* SHERYL FRANKLIN, Brazos River Authority, Waco, TX

**City of Austin Water and Wastewater Utility – Use Of Reclaimed Water At The New Austin Airport Location:** REBECCA COBOS, City of Austin, Austin, TX

**Flood Forecasting In The Lower Colorado River Basin – A Cooperative Effort Between LCRA and National Weather Service:** RANDY RIEMAN, Lower Colorado River Authority, Austin, TX and DAVID REED, National Weather Service, Slidell, LA

**Use Of Labyrinth Weir Dam For Flood Control And Improved Operation And Maintenance At Elemendorf Lake, San Antonio, Texas:** DORIAN FRENCH, Brown&Root, Inc., San Antonio, TX and STEVE RAMSEY, San Antonio River Authority, San Antonio, TX

**Hydrogeologic Investigations By The U.S. Geological Survey In The Edwards Aquifer Region:** REBECCA LAMBERT, U.S. Geological Survey, San Antonio, TX

SESSION T 9 *Blanco*

TEXAS HYDROLOGY I

*Moderator:* QUENTIN MARTIN, Lower Colorado River Authority, Austin, TX

**LCRA Hydrologic Studies Related To Dam Safety Of Highland Lakes:** RICK FRITHIOF, Lower Colorado River Authority, Austin, TX

**Modeling Surface Runoff To Playa Lakes:** DAVID THOMPSON and KEN RAINWATER, Texas Tech University, Lubbock, TX and ALAN J. REED, Parkhill, Smith, and Cooper,Inc., Lubbock, TX

**Reservoir Management Using Conditional Probability Analysis:** ALFREDO RODRIGUEZ and STEPHEN DENSMORE, Texas Water Development Board, Austin, TX

**Modeling Irrigation Districts With IRDDSS – A Tool For Conservation And Planning:** D.M. ENDALE and GUY FIPPS, Texas A&M University, College Station, TX

# THURSDAY, AUGUST 17, 1995

**8:30am - 10:00am**

CONCURRENT SESSIONS

SESSION T 10 *Nueces*

TRANS-TEXAS WATER PLAN I

*Moderator:* STEVEN J. RAABE, San Antonio River Authority, San Antonio, TX

**Overview And State of Texas Perspective on The Trans-Texas Water Program:** MIKE PERSONETT, Texas Water Development Board, Austin, TX

**The Trans-Texas Water Program – South-Central Study Area:** JAMES DODSON, City of Corpus Christi, Texas and HERB GRUBB and DAVID C. WHEELOCK, HDR Engineering, Inc., Austin, TX

**The Trans-Texas Water Program – West-Central Study Area:** STEVEN J. RAABE, San Antonio River Authority, San Antonio, TX and DAVID C. WHEELOCK, HDR Engineering, Inc., Austin, TX

**Potential Introduction of Aquatic Organisms From Interbasin Water Transfers In Southeast, South-Central and West-Central Texas:** JOSEPH KASBEY AND ROSS RASMUSSEN, Geo-Marine, Inc., Plano, TX

SESSION T 11 *Frio*

TEXAS RIVER-QUALITY

*Moderator:* CINDY LOEFFLER, Texas Parks&Wildlife Department, Austin, TX

**Contributions of the U.S. Geological Survey's National Water-Quality Assessment Program In Assessing The Quality of Water In Texas' Streams and Aquifers:** LARRY F.LAND and MARSHALL E. JENNINGS, U.S. Geological Survey, Austin, TX

**The TMDL Process: A Partnership To Achieve Texas' Water Quality Goals:** TROY C. HILL and R. BRAD JENNINGS, U.S. Environmental Protection Agency VI, Dallas, TX

**Is The Arroyo Colorado In Texas Polluted?:** GUY FIPPS and DAVID W. SMITH, Texas A&M University, College Station, TX

**Streamflow Data Collection and Water-Quality Monitoring By The U.S. Geological Survey In Texas:** FRANK C. WELLS, U.S. Geological Survey, Austin, TX

SESSION T 12 *Blanco*

TEXAS HYDROLOGY II

Moderator: JACK FURLONG, HDR Engineering, Inc., Dallas, TX

**Freshwater Inflows To Corpus Christi Bay National Estuary Program Study Area:** J.GREG MOSIER, WILLIAM ASQUITH and MARSHALL E. JENNINGS, U.S. Geological Survey, San Antonio and Austin, TX

**Intersection Of The Houston Ship Channel and Gulf Intracoastal Waterway, A Marine Simulator Navigation Study:** DENNIS W. WEBB, U.S.Army, Waterways Experiment Station, Vicksburg, MS

**Potential Of Improved Irrigation Technologies For Reducing Irrigation Water Use:** GUY FIPPS and R.M.SEYMOUR, Texas A&M University, College Station, TX

# The Lower Rio Grande Irrigation Conference

## Registration Form

me ______________________

mpany ______________________

y Time Phone ______________________

dress ______________________

y____________ State ______ Zip __________

LEASE REGISTER

______ Persons at $15 per person

ust be received by December 8, 1995. After
ecember 8, registration fee will be $20.

**Total Enclosed ($)**____________

AKE CHECKS PAYABLE TO:

**rigation Conference**

ETURN TO THE:

**Cameron County Extension Office,
Hidalgo County Extension Office, or
Starr County Extension Office**

MAIL TO:

**Ms. Pamela Baker
Agricultural Engineering Department
Texas A&M University
College Station, TX 77843-2117**

## Speakers

Joe Barrera, Manager, Brownsville Irrigation and Drainage District
Dr. Guy Fipps, Associate Professor and Extension Agricultural Engineer, Texas A&M University, College Station.
Gordon Hill, Manager, Bayview Irrigation District
John Hinojosa, Rio Grande River Water Master, TNRCC, McAllen
Glenn Jarvis, Attorney, McAllen
Alan Moore, Engineer, Natural Resources Conservation Service, San Benito
Leon New, Professor and Extension Agricultural Engineer, Texas A&M Center, Amarillo
Ray Prewett, General Manager, Texas Citrus Mutual
Jack Rabe, Manager, Donna Irrigation District
Dr. Julian Sauls, Professor and Extension Horticulturist, Texas A&M Center, Weslaco
David Smith, Extension Associate-Landscape Irrigation, Texas A&M University, College Station
Dr. Charles Stichler, Professor and Extension Agronomist, Texas A&M Center, Uvalde
Dr. Merritt Taylor, Extension Economist, Texas A&M Center, Weslaco
Bill Thompson, Manager, United Irrigation District, Mission
Don Thompson, President, TNT Associates, Garland
John Walker, Waterman Industries, Lubbock
Dr. Bob Wiedenfeld, Associate Professor - Soil Science, Texas A&M Center, Weslaco

## Conference Hotels

Reservations must be made by December 5, 1995 (mention the "*Irrigation Conference*" when making reservations). Free shuttle service to the civic center will be provided by both hotels.

**The Doubletree Club-Casa de Palmas** - 101 N. Main, McAllen, (800) 274-1102; (210) 631-1101): $49.95 single and $55 double.

**The Fairway Resort** - 2105 S. Tenth Street, McAllen
(800) 432-4792; (210) 682-2445): $50 for a single or double.
The Fairway can accommodate trailers and other large vehicles.

## For More Information

Contact:

Brad Cowan
Hidalgo County Extension Agent, Edinburg
(210) 383-1026

or

Dr. Guy Fipps
Associate Professor and Extension Agricultural Engineer,
Texas A&M University, College Station
(409) 845-7454

# THE LOWER RIO GRANDE IRRIGATION CONFERENCE

December 12, 1995
McAllen Civic Center

**Presented By the**

Texas Agricultural Extension Service
LRGV Irrigation District Managers' Association

**Sponsored by the**

Texas Water Development Board
Texas Agricultural Irrigation Association
Southmost Soil and Water Conservation District

# Texas Agricultural Extension Service

The Texas A&M University System

## ATTENDANCE RECORD

| RIO GRANDE VALLEY IRRIGATION CONFERENCE | DECEMBER 12,1995 |
|---|---|
| Activity or Event | Date |

Please sign in for our records

| | Name | Address | City | Zip | Phone |
|---|---|---|---|---|---|
| 1 | MIKE PERSONETT | TWDB PO. BOX 13231 | AUSTIN | 78711 | 512/463-806 |
| 2 | DALE MURDEN | RIO FARMS | EDCOUCH | 78538 | 262-387 |
| 3 | Kenneth Hood | 1213 westgate | weslaco | 78596 | 968-1752 |
| 4 | Carmelle [illegible] | 410 EAST 18 ST LOT 64 | WESLACO | 78596 | 968-414 |
| 5 | Bob BOECKER | P.O. Box 328 Alamo, Tx. | | 78516 | 781-52 |
| 6 | ERNIE P. GARCIA | 308A TEXAS BLVD | WESLACO | 78596 | 968-3174 |
| 7 | Bill Thompson | 216 country club | Mission | | |
| 8 | BILL PADEN | P.O. Box 1291 | HIDALGO | 78557 | 843-2591 |
| 9 | NEWT DYER | RT #1, BOX 116 A PHARR | PHARR | 78577 | 843-80 |
| 10 | JIM PAPE | RTE 30 BOX 1242 ~~MISSION~~ | MISSION | 78572 | 581-8788 |
| 11 | Jaime Sanchez | 1404 San Marcelo | BROWN | 78521 | 5427825 |
| 12 | Alvaro Rivera | Iturbide 9 | MAT. | | |
| 13 | JUAN M. MIÑANA | BOX 1772 | BROWNS | 78520 | 549 0328 |
| 14 | JoJo White | P.O. Box 237 | Mercedes | 78599 | 565-2411 |
| 15 | ROEL RAMIREZ. | P.O. Box 1001 | Roma | 78584 | 487 2582 |
| 16 | ENRIQUE PEREZ | 500 N. Britton TAEX | RGC | | |
| 17 | Linda Fernandez | TNRCC PO Box 13087 | Austin | 78711 | 512-239-5016 |
| 18 | Dewain Ritchie | United Irrigation P.O. Box 867 | MISSION | 78572 | 585-9818 |
| 19 | Bob D Olivarez | PO Box 994 | Mission | 78572 | 585-1661 |
| 20 | George Carpenter | Rt 7 Box 37-B | McAllen | 78504 | 383-5780 |

# Texas Agricultural Extension Service

The Texas A&M University System

## ATTENDANCE RECORD

| RIO GRANDE VALLEY IRRIGATION CONFERENCE | DECEMBER 12,1995 |
|---|---|
| Activity or Event | Date |

Please sign in for our records

| | Name | Address | City | Zip | Phone |
|---|---|---|---|---|---|
| 1 | Juan Leija | 913 N. Kenyon Rd | Edinburg | 78539 | 383-3686 |
| 2 | Harry Sullivan | 4116 old Winter Garden Rd | orlando | 32835 | 407 893-5535 |
| 3 | BILL TEHAN | 1609 WALNUT AVE. | McALLEN | 78501 | (210) 686-5872 |
| 4 | Gary A. Willms | Box 657 | Los Fresnos | 78566 | (210) 233 5232 |
| 5 | Albert M Kotzur | Rt 3 Box 161-A | Edinburg | 78539 | 210-982-341 |
| 6 | Jimmy Pawlik | P.O. Box 4467 | McAllen | 78502 | 210-686-503 |
| 7 | [illegible] | [illegible] | Hidalgo | 78557 | [illegible] |
| 8 | [illegible] Lopez | P.O. Box 1905 | Hgn. | 78551 | 423-1270 |
| 9 | Henry Willms | P.O. Box 361 | Harlingen | 78551 | 423-4412 |
| 10 | Ed Tracy | 1000 Ridge Rd | Alamo | 78516 | 781-1552 |
| 11 | Chuck Sullivan | 901 Business Park Dr., Ste 300 | Mission | 78572 | 584-1887 |
| 12 | Charles Hutchins | Box 494 ~~Castroville~~ | Castroville | 78009 | 5389712 |
| 13 | CLAIRE BROWN | Box 7158 4110 No Hwy 77 | HARLINGEN | 78552 | 428-9285 |
| 14 | RAY PENROD | 4110 N. HWY 77 #7272 | HARLINGEN | 78552 | 425-2014 |
| 15 | Arturo Vasquez | Rt. 2 Box 523-A | Weslaco | 78596 | 968-6028 |
| 16 | Jesus Ayala | 2415 E Hwy 83 | Weslaco | 78596 | 968-5585 |
| 17 | ERNEST GARCIA | 206 6th | Mercedes | 78570 | 514-2000 |
| 18 | Rafael Sierra | 206 6th | Mercedes | 78570 | 514-200 |
| 19 | Fuer Cortés | Sexta 24 | Gv. Díaz Ordaz | 88400 | 8-24-04 |
| 20 | | | | | |

# Texas Agricultural Extension Service

The Texas A&M University System

## ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE — Activity or Event

DECEMBER 12,1995 — Date

Please sign in for our records

| | Name | Address | City | Zip | Phone |
|---|---|---|---|---|---|
| 1 | Frank R. Ruiz | P. Box 295 B | Los Fresnos TX | 78586 | 210 399-[illegible] |
| 2 | Edelmira Garza E | Gladiolas #4 | Matamoros | 87330 | 13-36-86 |
| 3 | Gordon Hoki | 1500 Quamasia | McAllen | 78504 | 581-2226 |
| 4 | Koester, Larry | USDA-ARS ~~Weslaco~~ | Weslaco | 78596 | 969-4817 |
| 5 | JACK GARNER | HARLINGEN IRR. DIST. | HARLINGEN | 78550 | 423-9107 |
| 6 | James Peterson | 324 Oak | Rio Grande City | 78582 | 487-2571 |
| 7 | [illegible] | Box 1849 - Uvalde, Tx | Uvalde | 78802 | 210 278-915[illegible] |
| 8 | Bruce J. Lesikar | 306 Scoates Hall, College Station | College Station | 77843 | 409 845-7453 |
| 9 | Bill Friend | P.O. Box 158 | La Feria TX | 78559 | 210 797-242[illegible] |
| 10 | [illegible] | P.O. Box 246 | Pharr | 78577 | 787-3183 |
| 11 | Leon New | 6500 Amarillo Blvd. W. | Amarillo | 79106 | 806 359 5[illegible] |
| 12 | Doyle Warner | 2401 E Hy 83 | Weslaco | 78596 | [illegible] |
| 13 | K Chandler | RR 7 Bx 213Y | Edinburg | | 210 383-[illegible] |
| 14 | Alfredo Sanchez | | SATX | 78118 | 210-[illegible] |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |

SENT BY:Texas AG. Ext. Service 06-10-96 04:07PM 5123831735→ 8177733311 # 3

# Texas Agricultural Extension Service

The Texas A&M University System

## ATTENDANCE RECORD

| RIO GRANDE VALLEY IRRIGATION CONFERENCE | DECEMBER 12,1995 |
|---|---|
| Activity or Event | Date |

Please sign in for our records

| | Name | Address | City | Zip | Phone |
|---|---|---|---|---|---|
| 1 | Mario H Garza | 606 E 6 St | Mercedes | 78570 | 514-2000 |
| 2 | Bob H. Erat | RT 15 Box 7012-15 Mission | | | |
| 3 | Jim Williams | PO Box 2345 | McAllen | 78501 | 631-3011 |
| 4 | John Lightner | 3205 Cobblestone Dr. | Harlingen | 78550 | 421-2159 |
| 5 | Joe L. Harris | 2[illegible] Bougainvillea Dr | Mission | 78572 | 585-2347 |
| 6 | Genaro Cano | 1914 West Adrian | Harlingen | 78552 | 423-2086 |
| 7 | Ed Pierson | 10 N. Garfield | Eugene | 97440 | |
| 8 | Beth Mercer | PO Box 4157 | Monte Alto | 78538 | 262-1012 |
| 9 | Mont Pat Cobb | PO Box 337 | Shallowater | 79363 | 806 744 2071 |
| 10 | Margaret Johnston | PO Box 1043 | Mission | 78572 | 5854761 |
| 11 | [illegible] | P.O. Box 1043 | Mission | 78572 | 585-4761 |
| 12 | [illegible] Parker | PO Box 246-A | Harlingen | 78552 | 412-8568 |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |

[illegible] socioeconomic level, race, color, sex, religion, disability or national origin.

# Texas Agricultural Extension Service

The Texas A&M University System

## ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE
Activity or Event

DECEMBER 12,1995
Date

Please sign in for our records

| Name | Address | City | Zip | Phone |
|---|---|---|---|---|
| Juan Leija | 413 N. Kenyon Rd | Edinburg | 78539 | 383-3686 |
| | | | | 607 |

Texas Agricultural Extension Service
The Texas A&M University Syster

Rio Grande Valley

# Cotton Production & Physiology Workshop

Hoblitzelle Auditorium
Texas Agricultural Research & Extension Center - Weslaco
October 25, 1995
7:30 a.m.

**Registration Fee: $5.00 at the door**

| | |
|---|---|
| 7:30 - 8:00 a.m. | Registration ($5.00 at the door) |
| 8:00 - 12:00 | Water Situation Update - John Hinojosa |
| | Water Quality Issues - Dr. Guy Fipps, Extension Irrigation Specialist |
| | Managing for Earliness - Dr. Charles Stichler, Extension Agronomist |
| | Cotton Insect ID & Thresholds - John Norman, Extension Cotton Entomologist |
| | Stalk Destruction Update - Jimmy Day, Texas Department of Agriculture |
| | New Chemistries - Dr. Stormy Sparks, Extension Entomologist |
| | Budgeting the Cotton Crop - Dr. Merritt Taylor, Extension Economist |
| | Market Outlook - Dr. Carl Anderson, Extension Economist |
| 12:00 - 1:00 p.m. | Lunch (on your own) |
| | ******Optional Afternoon Session****** |
| 1:00 | Disaster Program Update - Marcos Garza, Consolidated Farm Services Agency |
| | Cotton Physiology Workshop - Dr. Charles Stichler, Extension Agronomist |

Sponsored by:

Texas Agricultural Extension Service
Cameron County Row Crops Committee
Hidalgo County Row Crops Committee
Willacy County Row Crops Committee

This program is worth three (3) hours of CEU's for commercial, non-commercial, and private applicators. For more information contact: Terry Lockamy - Cameron County (399-4412); Brad Cowan - Hidalgo County (383-1026); or Luis Saldaña -Willacy County (689-2412) 7757

Extension programs serve people of all ages regardless of socioeconomic level, race, color, sex, religion, disability or national origin.

# Texas Agricultural Extension Service

The Texas A&M University System

A 16 H 8 F 1

## ATTENDANCE RECORD

ACTIVITY Cotton Production Mtg DATE 10-25-95

**PLEASE SIGN IN FOR OUR RECORDS.**

| NAME | ADDRESS | CITY | ZIP | PHONE |
|---|---|---|---|---|
| Thomas Cavazos | RR.1-BOX-134A | LAFERIA | 78559 | 797-231[illegible] |
| [illegible] R Fike | Rt.1 BOX 348A | Edinburg | 78539 | 381-03[illegible] |
| Michael Fike | Rt.1 BOX 348A | Edinburg | 78539 | 383-64[illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| FRANK MACHAC JR. | 2504 CANTERBURY | MISSION | 78572 | 580-160[illegible] |
| [illegible] Bradford | 1203 W. 6th | Weslaco | 78596 | 968-5[illegible] |
| [illegible] | 508 S Tex | Weslaco | 78596 | 968-79[illegible] |
| Alex Keller | Rt 20 Box 816 | Mission | 78572 | 580-434[illegible] |
| D.E. Fagala | Rt 2 Box 152B | San Juan | 78589 | 783-574[illegible] |
| Bob Rektorik | Rt B. 409 | WESLACO | 78596 | 968-370[illegible] |
| Jim Gamble | Rt.1 Box 173 | La Feria | 78559 | 797-2[illegible] |
| Don Moskal | Rt 1 Box 211 | Santa Rosa | 78593 | 636-16[illegible] |
| Frank Krupala | Rt 2 Box 803 | Raymondville | 78580 | 689-6803 |
| Eric Alexander | 2102 North 7th #20 | Harlingen | 78550 | 425-2980 |
| Kurt F. Clay | Rt 1 Bx 39-K | La Feria | 78559 | 797-2[illegible] |
| Merritt J. Taylor | 2401 E Hwy 83 [illegible] | Weslaco | 78596 | 968-5[illegible] |
| LARRY W. KOESTER | 2401 E Hwy 83 Bldg 201 USDA | ARS Weslaco | 78596 | 969-4817 |
| Joel Garza | 2401 E Hwy 83 Bldg 203 USDA | Weslaco | 78596 | 969-485[illegible] |
| Richard Plata | Rt 5 Box 556 | San Benito | 78586 | 399-021[illegible] |
| Juan Leija (TAES) | 413 N. Kenyon Rd | Edinburg Tx | 78539 | 383-368[illegible] |
| Robert [illegible] | P.O. Box 111 [illegible] | Rio Hondo Tx | 78583 | 748-289[illegible] |
| Gary Willms | P.O. Box 657 | Los Fresnos | 78566 | 233-523[illegible] |
| Jesus [illegible] Perez | TAES | Weslaco | 78596 | 968-558[illegible] |
| Noe L. Hernandez | Rt 1 Box 115-A | Pharr | 78577 | 783-8662 |
| Celestino Aguirre | Rt Box 124 | Pharr | 78577 | 787-3177 |

# Texas Agricultural Extension Service

The Texas A&M University System

A H F
10 2 0

## ATTENDANCE RECORD

ACTIVITY Cotton Production Mtg DATE 10-25-95

PLEASE SIGN IN FOR OUR RECORDS.

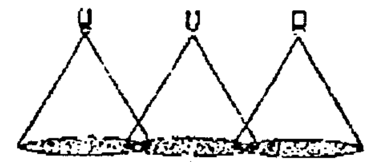
| NAME | ADDRESS | CITY | ZIP | PHONE |
|---|---|---|---|---|
| Heath Harris | 185 Lakeview D | San Benito, Tx | 78586 | 399-25 |
| [illegible] | 1701 South Oklahoma | Brownsville Tx | 78521 | 831-65 |
| [illegible] | 1855 S. Oklahoma | Brownsville Tx | 78521 | 831-431 |
| [illegible] | 8275 Oklahoma | Brownsville Tx | 78521 | 831-41 |
| [illegible] | 2401 E HWY 83 | Weslaco, Tx | 78596 | 968-55 |
| [illegible] | Rt. 1 Box 249 | La Feria Tx | 78559 | 797-11 |
| [illegible] Rodriguez | P.O. Box 1793 | Elsa Tx | 78543 | 782-88 |
| Bob Boecker | P.O. Box 328 | Alamo, Tx | 78516 | 781-5 |
| William [illegible] | R4 Box 224 | ~~San Benito~~ TX | 78586 | 399- |
| Mark [illegible] | 320 Quamasia | McAllen Tx | 78504 | 686-19 |
| E. Craig Smith | P.O. Box 511 | Hgn Tx | 78550 | 430-62 |
| Carlos Rivas | 2020 John Ave | Edinburg Tx | 78539 | 383-612 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | A H F | | |
| | | 10 2 0 | | |
| | | 15 4 3 | | |
| | | 13 12 6 | | |
| | | 16 8 1 | | |
| | | 54 26 4 | | |

# Texas Agricultural Extension Service

The Texas A&M University System

Hidalgo County Extension Office P.O. Box 600 Edinburg, TX 78540 210/383-1026


# COTTON PRE-PLANT MEETING and
## SPRAYER CALIBRATION CLINIC



Wednesday, January 17, ~~1995~~ 1996
Hoblitzelle Auditorium, A&M Research & Extension Center, Weslaco
3 TDA Recertification Credits to Be Offered for Private, Commercial and Non-Commercial Licenseholders

8:00- 8:30 Registration ($10.00 per person)
8:30- Noon Program

## ---------- SPEAKERS AND TOPICS ----------

**Update on Section 18's for Cotton in 1996**
*Terry Mitchell, Program Specialist- Texas Department of Agriculture, Austin*

**Moisture Management Strategies for the 1996 Crop**
*Kater Hake, Extension Agronomist, Lubbock*

**Calibration of Sprayers**
*Dr. Bryan Shaw, Extension Ag Engineering Specialist, College Station*

**Review of Cotton Variety Trials Conducted During the 1995 Crop**
*Brad Cowan, County Extension Agent- Agriculture, Edinburg*

**Drift Minimization Practices**
*Dr. Bryan Shaw, Extension Ag Engineering Specialist, College Station*

**Resistance Management, New Chemistries for Cotton**
*Dr. Stormy Sparks, Extension Entomologist, Weslaco*

**Farm Program Update**
*Wayne Labar, Executive Director, Cotton & Grain Producers Association*

---

I look forward to seeing you on the 17th.

Sincerely,

Brad Cowan
County Extension Agent- Agriculture, Hidalgo County

PAGE

TEXAS DEPARTMENT OF AGRICULTURE
P.O. BOX 12847, AUSTIN, TEXAS, 78711

# RECERTIFICATION ATTENDANCE FORM

Please furnish in accordance with recertification requirements, the items below, and have delivered promptly to the address listed above. Attendants must receive a certificate upon course completion as a receipt of attendance.

SPONSOR *(Name and Address)*

| COURSE # | COUNTY CODE# *Required for #5555 6666* | COURSE DATE |
|---|---|---|
| 2404 | | JANUARY 17, 1996 |

## NUMBER OF APPROVED CONTINUING EDUCATION CREDITS

| GENERAL | LAWS AND REGULATIONS | INTEGRATED PEST MGMT | DRIFT MINIMIZATION |
|---|---|---|---|
| | | | |

THIS INFORMATION MUST BE TYPED

| APPLICATOR'S NAME *(As it appears on the license)* | LICENSE # | SSN # | ADDRESS | CITY, STATE | ZIP |
|---|---|---|---|---|---|
| C. PRUKOP, JR | 186096 | | RT 8 BOX 160 | MISSION, TX | 78572 |
| L. SALDANA | 142596 | | 975 W GEM AVE | RAYMONDVILLE, TX | 78580 |
| E. HERENANDEZ | | 460-90-7298 | 2415 E. BUS. HWY 83 | WESLACO, TX | 78596 |
| J. PEREZ | | 449-66-1299 | RT 2 BOX 117 | MERCEDES, TX | 78570 |
| E. CASTANEDA | 136096 | | 108 BRUCE | MERCEDES, TX | 78570 |
| C. BAUER | | 456-62-7048 | P O BOX 1908 | LA FERIA, TX | 78559 |
| J. L. WILLIAMS | 122693 | | P O BOX 149 | LOS FRESNOS, TX | 78566 |
| C. EUBANKS | | 455-90-1029 | P O BOX 343 | SANTA ROSA, TX | 78593 |
| D. MCDANIEL | | 464-96-8830 | 1900 CITRUS | WESLACO, TX | 78596 |
| N. LYNN | | 457-60-6046 | RT 1 BOX 13A | ALAMO, TX | 78516 |
| L. BECK | | 480-74-2523 | P O BOX 720425 | MCALLEN, TX | 78504 |
| M. YEARY | | 463-29-3783 | P O BOX 278 | PROGRESO, TX | 78579 |
| L. JONES | | 449-27-7400 | BOX 1560 | MISSION, TX | 78572 |
| D. SHATLEY | | 571-88-2947 | BOX 40 | LOCKNEY, TX | 79241 |
| B. COWAN | 124558 | | P O BOX 600 | EDINBURG, TX | 78540 |
| P. ARNMANTROUT | | 369-14-9890 | RT 1 BOX 98K | ALAMO, TX | 78516 |
| D. G. WARREN | 122867 | | 2401 E HWY 83 | WESLACO, TX | 78596 |
| D. PETERS | | | RT 4 BOX 835 | SAN BENITO, TX | 78586 |
| W. HARRISON | | 461-40-1683 | 1202 ELM | MISSION, TX | 78572 |

TEXAS DEPARTMENT OF AGRICULTURE
P.O. BOX 12847, AUSTIN, TEXAS, 78711

# RECERTIFICATION ATTENDANCE FORM

Please furnish in accordance with recertification requirements, the items below, and have delivered promptly to the address listed above. Attendants must receive a certificate upon course completion as a receipt of attendance

SPONSOR *(Name and Address)*

| COURSE # | COUNTY CODE# *Required for #5555 6666* | COURSE DATE |
|---|---|---|
| 2404 | | JANUARY 17, 1996 |

## NUMBER OF APPROVED CONTINUING EDUCATION CREDITS

| GENERAL | LAWS AND REGULATIONS | INTEGRATED PEST MGMT | DRIFT MINIMIZATION |
|---|---|---|---|
| | | | |

THIS INFORMATION MUST BE TYPED

| APPLICATOR'S NAME *(As it appears on the license)* | LICENSE # | SSN # | ADDRESS | CITY, STATE | ZIP |
|---|---|---|---|---|---|
| MANUEL VEGA | 172674 | | 2415 E HWY 83 | WESLACO, TX | 78596 |
| B. FELDING | 125956 | | P O BOX 4448 | BROWNSVILLE, TX | 78523 |
| J. KIMBRIEL | | | 2342 S. 25TH ST. | HARLINGEN, TX | 78550 |
| B.SNIDER | | 430-54-3029 | 113 E COOLDGE | HARLINGEN, TX | 78550 |
| W. ALLEN COHRS | | 454-04-3004 | RT 4 BOX 4360 | DONNA, TX | 78537 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

3 Shallow Wave

# 1996 NO-TILL FIELD DEMONSTRATION

## CAMERON COUNTY FIELD CROPS COMMITTEE

at WILBUR-ELLIS, RIO HONDO -(follow signs)

REGISTRATION: 8:30 A.M.

25 Multi-Wave

JUNE 12, 1996
2 CEU CREDITS

REGISTRTION: 8:30 A.M.
LUNCH PROVIDED

FEATURING: Demonstrations of No-Till Planters & Cultivators

| | |
|---|---|
| John Deere | Yetter |
| Buffalo | Dawn |
| | Groft |
| | Martin |

Cultivating to create a Water Furrow
Water Conservation Displays
Boll Weevil Parasite Display - Catolaccus grandis

TECHNICAL ASSISTANCE: USDA-ARS, NRCS, TAEX-TAES & BARBEE NEUHAUS

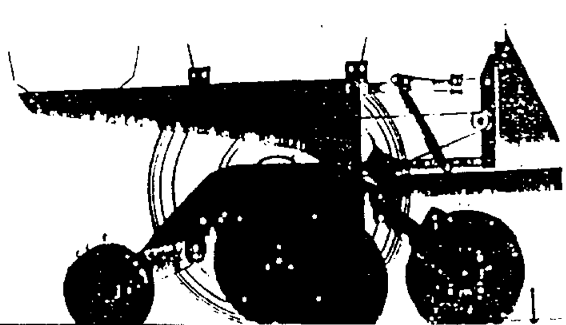
SPECIAL GUESTS: TAMAULIPAS GROWERS ASSOCIATION

The following sponsors made this day possible:

| | |
|---|---|
| Texas State Bank | Harlingen Irrigation District #1 |
| PCA | San Benito Irrigation District #2 |
| San Benito Bank& Trust | La Feria Irrigation District #3 |
| First National Bank of San Benito | Valco |
| First Valley Bank | Southmost Soil & Water Conservation District |
| Brownsville Nat'l Bank | |

ASOCIACION AGRICOLA DE MATAMOROS
WILBUR-ELLIS

Ripple



Bubble

Faxed
2-14-97

UNITED STATES
DEPARTMENT OF
AGRICULTURE

NATURAL RESOURCES
CONSERVATION
SERVICE

2315 W EXPWY 83
SAN BENITO, TEXAS 78586
PHONE: (210) 399-2522

To: Justin Hester
TSSWCB Project Officer
Texas State Soil and Water Conservation Board
P.O. Box 658
Temple, Texas 76501

Date: February 13, 1997

Subject: NPS Prevention in Arroyo Colorado Watershed
NRCS Quarterly Report-September thru November 1996

TASK 4.0 Annual Education Workshop Conducted

The Extension Service in cooperation with NRCS, SWCD and Cameron County Crops Committee sponsored a conservation field day at the Gearge Labar farm in Rio Hondo. Alan Moore, Ag Engineer, NRCS, San Benito spoke about and demonstrated the monitoring equipment and sampling procedures at the demonstration site. Tony Gonzales, DC, NRCS spoke on BMP's including rotation cropping system, conservation tillage, precision land forming, nutrient management and pest management. Jim Childers, Agronomist, NRCS also spoke on conservation tillage and BMP's as applicable to dryland farming. Planting in heavy standing residue was demonstrated. About 100 producers attended. The field day was held on October 23, 1996 (agenda attached).

Other NRCS activities during this quarter included:

1. Visited with producers Wayne Halbert and George Labar about managing crop residues, fertilizer application and irrigation water management.

2. Coordinated sample collection and equipment maintenance with Agro-Synergetics, John Lightner.

3. Ordered new set of bottles for sample collecting.

4. Ordered new data loggers for all sites.

5. Assisted SWCD with clerical duties relating to the project.

Sincerely,

Antolin Gonzales

Antolin Gonzales
District Conservationist

Presented by: Cameron County Crops Committee

Committed to the future of agriculture.

Cooperating Sponsors:

- Cameron County Extension Office
- Natural Resource Conservation Service
- Southern Regional Sustainable Agricultural Research and Education Program
- Southmost Soil & Water Conservation District
- Texas Agricultural Extension Service
- USDA-Agricultural Research Service
- U.S.E.P.A. - Arroyo Colorado Project

## Cameron County Field Crops Committee

# 2nd Annual

**No-Till Field Day &**
**Farm Show**
**Rangerville Coop Gin**
**April 30, 1997**
**9:00 a.m. - Noon**
**Lunch Provided**

**3 CEU's and Door Prizes**

Committed to the future of agriculture.

CEU'S

B.B.Q. Lunch

# Conservation Tillage Field Day
## October 23, 1996
## Registration and coffee 8:00 a.m.
## Tour starts at 8:30
## George Labar Farm Headquarters
(FM 1420, across from Camp Perry on West side of Road)

Managing Soil Moisture:
- -Estimating available moisture
- -Estimating crop usage rate
- -Impacts on decision making

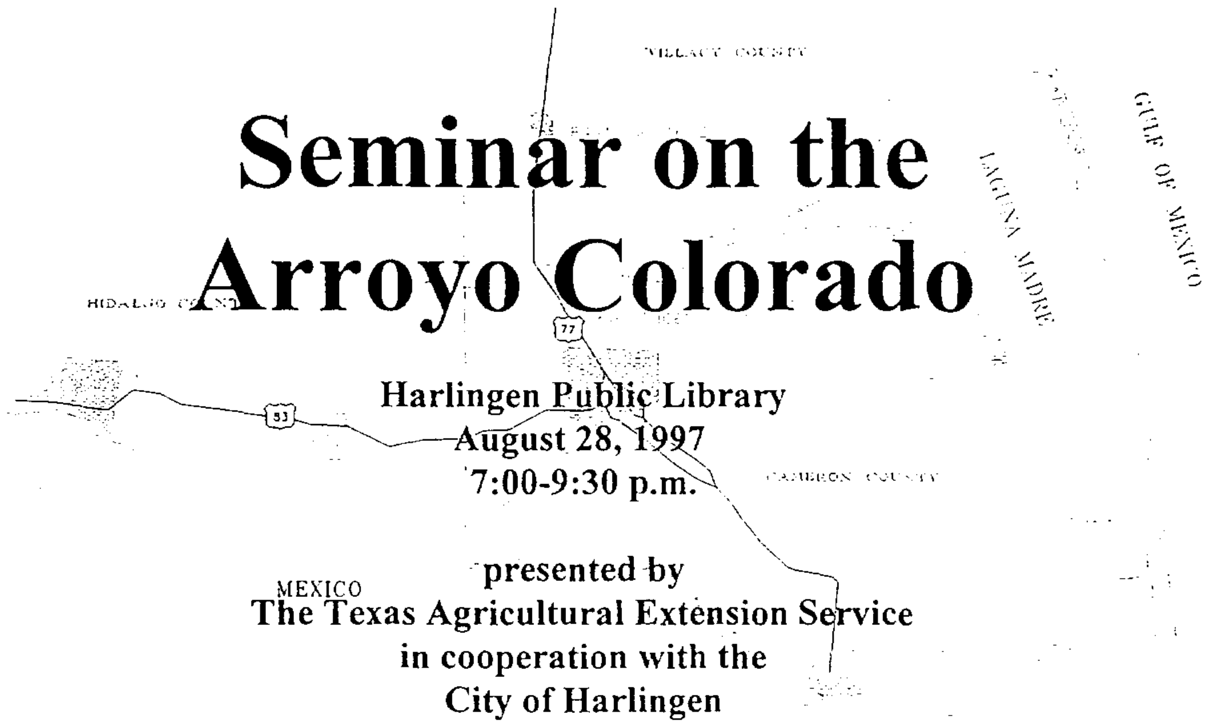
Best Management Practices:
- -reduce Nitrogen losses
- -reduce moisture losses
- -reduce land preparation costs
- -reduce non point source pollution potential
- -Water Quality Issues
- -Senate Bill 503 - requirements and incentives

Equipment Demonstration & Displays:
- -Planting in heavy residue
- -Fertilizer applications in residue
- -Residue managers for planting, cultivating, and off season weed control
- -Herbicide application

Hosted by:
Cameron County Field Crops Committee
Southmost Soil & Water Conservation District
Texas Agricultural Extension Service
Natural Resource Conservation Servic
USDA-Agr. Research Service

Equipment provided by:
Barbee-Neuhaus Implement Co

Sponsored by:
Monsanto
Southmost Soil & Water Conservation District
Asociaccion Agricola De Matamoros
Brownsville National Bank
San Benito Irrigation Dist. #2
First National Bank - San Benito
First Valley Bank
Harlingen Irrigation Dist. #1
La Feria Irrigation Dist. #3
Production Credit Association
San Benito Bank & Trust
Southmost Soil & Water Conservation District
Texas State Bank-
Valley Co-Op Oil Mill




# Seminar on the Arroyo Colorado

**Harlingen Public Library**
**August 28, 1997**
**7:00-9:30 p.m.**

**presented by**
**The Texas Agricultural Extension Service**
**in cooperation with the**
**City of Harlingen**

**Description**
The Seminar will present the results of the multi-agency project: ***Non-point Source Pollution Prevention in the Arroyo Colorado Watershed***. The project was funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). Cooperating agencies included the Natural Resources Conservation Service (NRCS), the Southmost Soil and Water Conservation District, the Texas Institute for Applied Environmental Research (TIAER), and the Texas Agricultural Extension Service (TAEX).

**Program**

| | |
|---|---|
| 7:00 p.m. | **Welcome, Project Overview**<br>T. Lockamy, G. Fipps, B. Spoonts, L. Pardee (invited) |
| 7:30 | **The Arroyo Colorado Water Quality Data Base - What do we know?**<br>C. Bausch, G. Fipps |
| 8:00 | **Demonstration Sites and Results**<br>T. Gonzales, A. Moore |
| 8:30 | **Best Management Practices - Modeling and Projected Benefits**<br>J. Flowers |
| 9:00 | **Educational Program Outcomes**<br>G. Fipps, D. Smith, S. Sparks, B. Shaw |
| 9:30 | **Adjourn** |

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

On-Farm 8/15/95

| | | |
|---|---|---|
| Conney Fick | TWDB | 512-463-7983 |
| Jeff Walker | TWDB | 512 463-7940 |
| DAROLD ARBUTHNOT | BUREAU OF RECLAMATION | 652-247-7776 |
| OSVALDO LONGORIA JR. | NRCS | 210-[illegible]-2542 |
| ROEL E. TREVINO | NRCS | 210-383-3002 |
| Paul DeArman | NRCS | 512-239-4729 |
| BRAD Cowan | Texas Agricultural Extension Service | 383-1026 |
| Alan Moore | NRCS | 210-399-2522 |
| BAILEY H. DUNLAP JR | SSWCD #319 | 1210 797 2561 |
| WAYNE HALBERT | HARLINGEN IRRIGATION | 210 423 7015 |
| Terry Lockamy | Tx Ag. Ext. Service - Cameron Co. | 210 399 4412 |
| Lenny Duberstein | U.S. BOR. - Billings MT | 406-247-7707 |
| Tony Gonzales | USDA, NRCS | 210-399-2522 |
| Alberto Ramirez | TSSWCB - Edinburg | 210-381-6614 |
| Doyle G Warren | TAEX | 210 968 5581 |
| John M. Sweeten | Ag Eng Dept. College Station TX TX Ag Extension Service, TX A&M Univ. | 409/845-7451 |
| JAMES KOWIS | TNRCC / Austin | (512) 239-4706 |
| LINDA FERNANDEZ | TNRCC / Austin | 512-239-5016 |
| Guy Fipps | Ag Eng, TAMU/TAEX | 409 845-7454 |
| Bill Thompson | United Irrigation | 210 585-4818 |
| DARIUSZ SWIETLIK | TEXAS A&M-Kingsville Citrus Center | 210-968-[illegible] |
| MIKE PERSONETT | TWDB | 512/463-8061 |